# TE LINDE'S

# Operative Gynecology

THIRTEENTH EDITION

LINDA VAN LE | VICTORIA L. HANDA

Wolters Kluwer

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# PREFACE

This is the 13th edition of *Te Linde's Operative Gynecology* and our second edition as editors. We took the helm of this revered and classic textbook following in the footsteps of great leaders in gynecology: Drs. Richard Te Linde, Richard Mattingly, John Thompson, John Rock, and Howard Jones III. Over 70 years and 12 editions, our predecessors created "an irreplaceable reference for generations of gynecologic surgeons." Over time, this textbook has become a resource for gynecologic surgeons around the world. The 12th edition sold very well in North America, Central America, South America, and Europe. The textbook has been translated into Spanish, Russian, Chinese, and Turkish.

For the 12th edition, we added new elements and refocused on operative procedures. Chapters on safe positioning, surgical instrumentation, management of müllerian abnormalities and pediatric gynecologic disorders, and a primer on anesthesia were added. Four years has elapsed and in response to changing gynecologic practice and the advent of new procedures, all chapters have been updated and we have added additional sections. In addition to the primer on anesthesia, a primer on radiologic procedures has been added to give a quick summary of common procedures we order in the course of our gynecologic management. A new chapter on critical care is included as well as a new chapter on laparoscopy. Our colleagues updated the chapter on management of surgical hemorrhage and added guidance on management of placenta accreta spectrum. Novice surgeons have really appreciated the chapter on surgical technique and instruments and have found this to be a great resource as they begin their surgical practices. In the chapter on robotics, there is an expanded section and video to address the difficult extraction of large masses.

The Te Linde textbook has been a respected source of surgical information for generations of gynecologic surgeons. We are

honored to contribute to its valued legacy.

We hope this 13th edition will serve as a valued resource as you continue your careers as gynecologic surgeons providing the best care possible to all of our patients.

**Linda Van Le, MD**
**Victoria L. Handa, MD**

# PREFACE FROM FIRST EDITION

Gynecology has become a many-sided specialty. No longer is it simply a branch of general surgery. In order to practice this specialty in its broad sense, the gynecologist must be trained in a comprehensive field. He must be a surgeon, expert in his special field, he must be trained in the fundamentals of obstetrics, he must have the technical skill to investigate female urologic conditions, he must have an understanding of endocrinology as it applies to gynecology, he should be well grounded in gynecologic pathology, and finally, he must be able to recognize and deal successfully with minor psychiatric problems that arise so commonly among gynecologic patients. With this concept of the specialty in mind, this book has been written. It then becomes apparent, when one seeks training in gynecology beyond the simplest fundamentals such as are taught to undergraduates, that special works are necessary for training those who intend to practice it. The author is a firm believer in the system of long hospital residencies for training young men in the various surgical specialties when their minds are quick to grasp ideas and their fingers are nimble. This volume has been written particularly for this group of men. Unfortunately, there is a paucity of good gynecologic residencies in the United States in the sense that the author has in mind. Many positions bear the name of residency but fail to give the resident sufficient operative work to justify the name. Another excellent method of development of the young gynecologist is an active assistantship to a well-trained, mature gynecologist. If the assistant is permitted to stand at the operating table opposite his chief day after day, eventually he will acquire skill and judgment which he himself will be able to utilize as an operator. When such a preceptorsystem is practiced, it is important that the assistant be given some surgery of his own to do while he is still

young. If a man is forced to think of himself only as a perennial assistant, this frame of mind will kill his ability to accept responsibility of his own. However, many must learn their operative gynecology under less favorable circumstances than those of the fortunate resident or assistant. This volume should be of value to those who, by self-instruction, must acquire a certain degree of operative skill. Finally, it must be admitted that more gynecology is practiced today by general surgeons in this country than by gynecologists. Although this is not ideal, circumstances make it necessary, and much of this gynecologic surgery is well done. It is hoped that many general surgeons will use this volume as a reference book.

In connection with general surgery, it is only fair to say that much has come to gynecology by way of general surgeons of the old school, who practiced general surgery in the broadest sense. Now that gynecology and/or obstetrics has become a specialty unto itself, it is well in our training of men not to swing too far from general abdominal surgery. In spite of the most careful preoperative investigation, mistakes in diagnosis will be made, and at times, the gynecologist will be called upon to take care of general surgical conditions in the region of lower abdomen and the rectum. With this in mind, the author has included in this volume a consideration of a few of the commoner general surgical conditions occasionally encountered incident.

**Dr. Richard Te Linde**
**1946**

# CONTENTS

Contributors

Video Contributors

Preface

Preface from First Edition

Video Contents

## SECTION I
## Preparing for Surgery

1 Surgical Anatomy of the Female Pelvis
**Marlene M. Corton and John O. L. DeLancey**

2 Preoperative Care of the Gynecologic Patient
**Khara M. Simpson and Karen C. Wang**

## SECTION II
## Basic Principles of Gynecologic Surgery

3 Anesthesia Primer for the Gynecologist
**Christine P. McKenzie**

4 Radiology Primer for the Gynecologist
**Ersan Altun and Kristen Olinger**

5 Patient Positioning for Pelvic Surgery
**Kimberly Kenton and Margaret G. Mueller**

6 Surgical Techniques, Instruments, and Suture
**John T. Soper**

7 Principles of Electrical and Laser Energy Applied to Gynecologic Surgery
**Magdy P. Milad and Ted L. Anderson**

8 Incisions for Gynecologic Surgery
**James J. Burke II**

9 Principles of Laparoscopy
**Amanda Yunker**

10 Principles of Robotic Surgery
**Arnold P. Advincula and Sierra J. Seaman**

## SECTION III
## Postoperative Care

11 Postoperative Care of the Gynecologic Patient
**Rajiv B. Gala**

12 Postoperative Infections in Gynecologic Surgery
**Anna Powell**

13 Critical Care of the Gynecologic Patient
**Duncan J. McLean and William M. Hart**

## SECTION IV
## Contemporary Gynecologic Surgical Procedures

14 Dilation and Curettage
**Ronald T. Burkman and Heather Z. Sankey**

15 Hysteroscopy
Mindy S. Christianson and Kristin E. Patzkowsky

16 Surgical Management of Abortion and Its Complications
Amy G. Bryant and Chava Kahn

17 Surgery for Benign Vulvar Conditions
Heather Z. Sankey and Ronald T. Burkman

18 Tubal Sterilization
Amy G. Bryant and Jessica E. Morse

19 Surgery of the Ovary and Fallopian Tube
Sarah L. Cohen Rassier and Antonio R. Gargiulo

20 Surgical Management of Ectopic Pregnancy
Katharine O'Connell White and Paula M. Castaño

21 Myomectomy
Linda D. Bradley and Tommaso Falcone

22 Vaginal Hysterectomy
John A. Occhino and John B. Gebhart

23 Abdominal Hysterectomy
Laurie S. Swaim and Audra E. Timmins

24 Minimally Invasive Hysterectomy-Laparoscopic and Robotic-Assisted Hysterectomy
Ted L. Anderson and Ronald D. Alvarez

SECTION V
Gynecologic Oncology

25 Surgery for Preinvasive Disease of the Cervix
**Leslie H. Clark**

26 Surgery for Preinvasive and Invasive Disease of the Vulva and Vagina
**Ryan J. Spencer and David M. Kushner**

27 Surgery for Uterine Cancer
**Edward Tanner**

28 Surgery for Cervical Cancer
**Nadeem R. Abu-Rustum and Vance A. Broach**

29 Surgery for Ovarian Cancer
**Ritu Salani and Mae Zakhour**

## SECTION VI
## Surgery for Pelvic Floor Disorders

30 Transvaginal Apical Suspensions for Uterovaginal Prolapse
**Robert E. Gutman**

31 Sacrocolpopexy
**Anthony G. Visco**

32 Colporrhaphy and Enterocele Repair
**Cara Grimes and Patrick Popiel**

33 Midurethral Slings and Surgery for Stress Urinary Incontinence
**Renée M. Ward**

34 Colpocleisis

Melinda G. Abernethy

35 Vesicovaginal and Rectovaginal Fistula
Chi Chiung Grace Chen and Jaime Bashore Long

36 Repair of Episiotomy and Complex Perineal Lacerations
Dana R. Gossett and Christina Lewicky-Gaupp

SECTION VII
Complications of Pelvic Surgery

37 Management of Intraoperative Complications to the Urinary Tract
E. James Wright

38 Management of Operative Complications to the Gastrointestinal Tract
Mitchel Hoffman and Emmanuel E. Zervos

39 Management of Surgical Hemorrhage
Emma Rossi

SECTION VIII
Surgical Management of Selected Gynecologic Conditions

40 Surgical Management of Pelvic Pain and Endometriosis
Matthew T. Siedhoff and Erin T. Carey

**41** Surgical Management of Pelvic Inflammatory Disease
**Matthew T. Siedhoff and Michelle Louie**

**42** Surgical Management of Reproductive Tract Anomalies
**Jennifer E. Dietrich**

**43** Pediatric and Adolescent Gynecologic Surgery
**Geri Hewitt**

**44** Surgery for Obstetric Hemorrhage
**Jason D. Wright and Fady Khoury-Collado**

*Index*

# VIDEO CONTENTS LIST

## SECTION II
## Basic Principles of Gynecologic Surgery


**CHAPTER 6** Surgical Techniques, Instruments, and Suture

VIDEO 6.1 Using the Bookwalter Retraction System

**CHAPTER 7** Principles of Electrical and Laser Energy Applied to Gynecologic Surgery

VIDEO 7.1 Take Charge in the OR: Tips for Safe use of Monopolar Devices

**CHAPTER 9** Principles of Laparoscopy

VIDEO 9.1 Optimizing Visualization in the Pelvis: When more Trendelenburg is not Enough

VIDEO 9.2 Peritoneal Entry Techniques

VIDEO 9.3 Avascular Planes of the Pelvis

**CHAPTER 10** Principles of Robotic Surgery

VIDEO 10.1 Robotic Port Placement

VIDEO 10.2 Right-Sided Robotic Docking

VIDEO 10.3 Robotic Specimen Bagging and Removal

VIDEO 10.4 Tissue Morcellation with ExCITE

VIDEO 10.5 Robotic-Assisted Laparoscopic Myomectomy

VIDEO 10.6 Robotic-Assisted Laparoscopic Transabdominal Cerclage

VIDEO 10.7 Robotic-Assisted Laparoscopic Excision of Deep Infiltrating Endometriosis

VIDEO 10.8 Robotic-Assisted Laparoscopic Isthmocele Repair

VIDEO 10.9 Robotic-Assisted Total Laparoscopic Hysterectomy

**SECTION IV**
**Contemporary Gynecologic Surgical Procedures**

**CHAPTER 18** Tubal Sterilization

VIDEO 18.1 Laparoscopic Bilateral Salpingectomy

**CHAPTER 19** Surgery of the Ovary and Fallopian Tube

VIDEO 19.1 Robotic Tubal Reanastomosis: The Brigham Technique

**CHAPTER 21** Myomectomy

VIDEO 21.1 Fertility Preserving Robotic-Assisted Laparoscopic Myomectomy

## CHAPTER 22 Vaginal Hysterectomy

VIDEO 22.1 Initial Incision for Vaginal Hysterectomy

VIDEO 22.2 Incision and Anterior and Posterior Entry for Vaginal Hysterectomy

VIDEO 22.3 Incision with Posterior Entry for Vaginal Hysterectomy

VIDEO 22.4 Vaginal Hysterectomy

VIDEO 22.5 Difficult Anterior Entry for Vaginal Hysterectomy

VIDEO 22.6 Cervical Elongation in Vaginal Hysterectomy

VIDEO 22.7 Vaginal Hysterectomy with Morcellation for the Enlarged Uterus

VIDEO 22.8 Bilateral Salpingectomy after Vaginal Hysterectomy

VIDEO 22.9 Techniques dor Vaginal Oophorectomy

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## CHAPTER 24 Minimally Invasive Hysterectomy-Laparoscopic and Robotic-Assisted Hysterectomy

VIDEO 24.1 Approach to Laparoscopic Hysterectomy of Large Fibroid Uteri

VIDEO 24.2 Approaches to Isolating the Uterine Artery at its Origin from the Internal Iliac Artery

VIDEO 24.3 Total Laparoscopic Hysterectomy with Retroperitoneal Identification of Ureters: a Standard Approach

## SECTION V
## Gynecologic Oncology

### CHAPTER 27 Surgery for Uterine Cancer

VIDEO 27.1 Technique for Robotic-Assisted Endometrial Cancer Staging with Sentinel Lymph Node Mapping

VIDEO 27.2 Robotic-Assisted Hysterectomy and Sentinel Lymph Node Mapping for Low-Grade Endometrial Cancer

VIDEO 27.3 Technique for Sentinel Lymph Node Mapping for Endometrial Cancer

### CHAPTER 28 Surgery for Cervical Cancer

VIDEO 28.1 Hysterectomy with Radical Dissection

### CHAPTER 29 Surgery for Ovarian Cancer

VIDEO 29.1 Laparoscopic Para-Aortic and Pelvic Lymph Node Dissection

## SECTION VI
## Surgery for Pelvic Floor Disorders

### CHAPTER 31 Sacrocolpopexy

VIDEO 31.1 Robotic Sacrocolpopexy

### CHAPTER 36 Repair of Episiotomy and Complex Perineal Lacerations

VIDEO 36.1 Repair of Rectovaginal Fistula, External Anal Sphincteroplasty, and Perineorrhaphy

## SECTION VII
## Complications of Pelvic Surgery

### CHAPTER 38 Management of Operative Complications to the Gastrointestinal Tract

VIDEO 38.1 Enterotomy Closure

VIDEO 38.2 Laparoscopic Appendectomy

VIDEO 38.3 Open Appendectomy

VIDEO 38.4 Small Bowel Anastomosis

### CHAPTER 39 Management of Surgical Hemorrhage

VIDEO 39.1 Robotic Repair of Left External Iliac Artery Injury

## SECTION VIII
## Surgical Management of Selected Gynecologic Conditions

### CHAPTER 40 Surgical Management of Pelvic Pain and Endometriosis

VIDEO 40.1 Laparoscopic Excision of Endometriosis

# CHAPTER 42 Surgical Management of Reproductive Tract Anomalies

VIDEO 42.1 Redefining Pelvic Landmarks in Patients with Müllerian Anomalies Undergoing Hysterectomy

# SECTION I

# Preparing for Surgery


1 SURGICAL ANATOMY OF THE FEMALE PELVIS
Marlene M. Corton and John O. L. DeLancey

2 PREOPERATIVE CARE OF THE GYNECOLOGIC PATIENT
Khara M. Simpson and Karen C. Wang

# CHAPTER 1

# SURGICAL ANATOMY OF THE FEMALE PELVIS

Marlene M. Corton and John O. L. DeLancey

**The Abdominal Wall**
Skin and Subcutaneous Tissue
Musculoaponeurotic Layer
Neurovascular Supply of the Abdominal Wall
Other Lumbar Plexus Branches
**Vulva and Erectile Structures**
Subcutaneous Tissues of the Vulva
Superficial Compartment
Pudendal Nerve and Vessels
Terminal Branches of Pudendal Nerve
Autonomic Innervation to Erectile Structures
Lymphatic Drainage
Medial Thigh Compartment
**The Pelvic Floor**
Perineal Membrane
Perineal Body
Posterior Triangle: Ischioanal Fossa
Anal Sphincters

Levator Ani Muscles

**Pelvic Viscera**

Genital Structures

Lower Urinary Tract

Sigmoid Colon and Rectum

**Pelvic Connective Tissue**

Uterine Ligaments

Vaginal Connective Tissue Attachments

Urethral Support

**Extraperitoneal Surgical Spaces**

Anterior and Posterior Cul-De-Sacs

Retropubic/Prevesical Space

Vesicovaginal and Vesicocervical Space

Rectovaginal Space

Region of the Sacrospinous Ligament and Greater Sciatic Foramen

**Retroperitoneal Spaces and Lateral Pelvic Wall**

Retroperitoneal Structures Above the Pelvic Brim

Presacral Space

Pelvic Retroperitoneal Space

Lymphatics

# THE ABDOMINAL WALL

The superior border of the abdominal wall is the lower edge of the rib cage (ribs 7 through 12). The inferior margin is formed by the iliac crests, inguinal ligaments, and pubic bones. It ends posterolaterally

at the lumbar spine and its adjacent muscles. Knowledge of the layered structure of the abdominal wall allows the surgeon to enter the abdominal cavity with maximum efficiency and safety. A general summary of these layers is provided in **TABLE 1.1** and discussed below.

## TABLE 1.1
## Abdominal Wall Layers

| NERVE | ROOT | FIBER TYPE | INNERVATION | SYMPTOMS | VULNERABILITY |
|---|---|---|---|---|---|
| Ilioinguinal<br>Iliohypogastric | L1 | Afferent | Internal oblique<br>Transversus abdominis<br>Labia majora | Burning pain, paresthesia at incision radiates | Low transverse incisions<br>Lower quadrant ports<br>Self-retaining retractors |
| Lateral femoral cutaneous | L2-L4 | Afferent | Lateral thigh | Pain and paresthesia anterior lateral thigh to knee | Hip flexion<br>Self-retaining retractors |
| Femoral | L2-L4 | Afferent<br>Efferent | Quadriceps<br>Anterior thigh<br>Medial leg | Unable to<br>• Flex hip<br>• Extend knee<br>• Adduct thigh<br>Hypoesthesia anterior thigh<br>Absent patellar reflex | Self-retaining retractors<br>Excessive hip flexion |
| Obturator | L2-L4 | Afferent<br>Efferent | Adductors<br>Medial thigh | Unable to adduct thigh<br>Hypoesthesia medial thigh | Prolonged hip flexion<br>Retropubic dissection |
| Sciatic | L4-S3 | Afferent<br>Efferent | Hamstrings<br>Posterior thigh<br>Lateral leg | Pain down posterior leg<br>Unable to<br>• Extend thigh<br>• Flex leg<br>Hypoesthesia of the posterior thigh, calf, and sole of the foot<br>Absent Achilles reflex | Hyperflexion of the hip<br>Extension of the leg |
| Common peroneal | L4-S2 | Afferent<br>Efferent | Anterior leg | Footdrop<br>Unable to dorsiflex foot<br>Hypoesthesia of the lateral leg and foot | Extension and rotation of the hip<br>Extension of the knee<br>Lateral pressure of the fibula |
| Pudendal | S2-S4 | Afferent<br>Efferent | Striated urethral sphincter<br>External anal sphincter<br>Clitoris, perineal and perianal skin | Stress incontinence<br>Fecal incontinence<br>Pelvic pain | Vaginal childbirth |

# Skin and Subcutaneous Tissue

The fibers in the dermal layer of the abdominal skin are oriented in a predominantly transverse direction following a gently curving upward line. This predominance of transversely oriented fibers results in more tension on the skin of a vertical incision and in a wider scar.

Deep to the skin lies the subcutaneous tissue of the abdomen. This tissue is made of globules of fat held in place and supported by

a series of branching fibrous septa. In the more superficial portion of the subcutaneous tissue, called the fatty layer (formerly Camper *fascia*), fat predominates, and fibrous tissue is less apparent. Closer to the rectus sheath, the fibrous tissue predominates relative to the fat, and this portion of the subcutaneous layer is called the membranous layer (formerly Scarpa *fascia*). The fatty and membranous layers are not discrete or well-defined layers but represent regions within the subcutaneous tissue. The membranous layer is best developed laterally and is not seen as a well-defined layer during midline vertical incisions. It is most evident at the lateral borders of low transverse incisions, just above the rectus sheath.

## Musculoaponeurotic Layer

Deep to the subcutaneous tissue is a layer of muscle and fibrous tissue ("fascia") that holds the abdominal viscera in place and controls movement of the lower torso (**FIGS. 1.1 and 1.2**). The muscles of this layer can be considered in two groups: the vertical muscles in the midline (rectus abdominis and pyramidalis) and the more lateral flank muscles (the external oblique, internal oblique, and transversus abdominis). The fascia, properly called the rectus sheath, is created by the broad, sheetlike tendons of these muscles, which form aponeuroses that unite with their corresponding member of the other side.

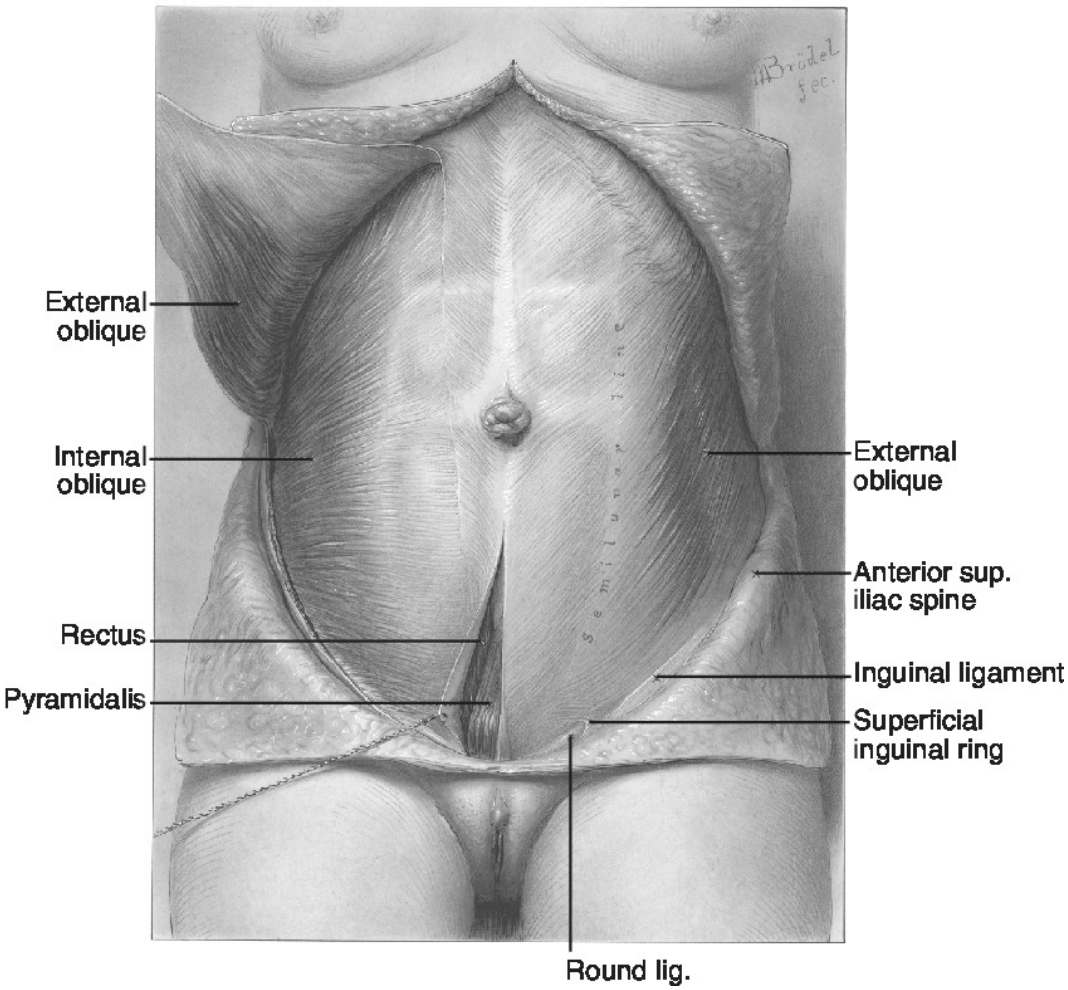


**FIGURE 1.1** External oblique, internal oblique, and pyramidalis muscles. (The original illustration is in the Max Brödel Archives in the Department of Art as Applied to Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA. Used with permission.)

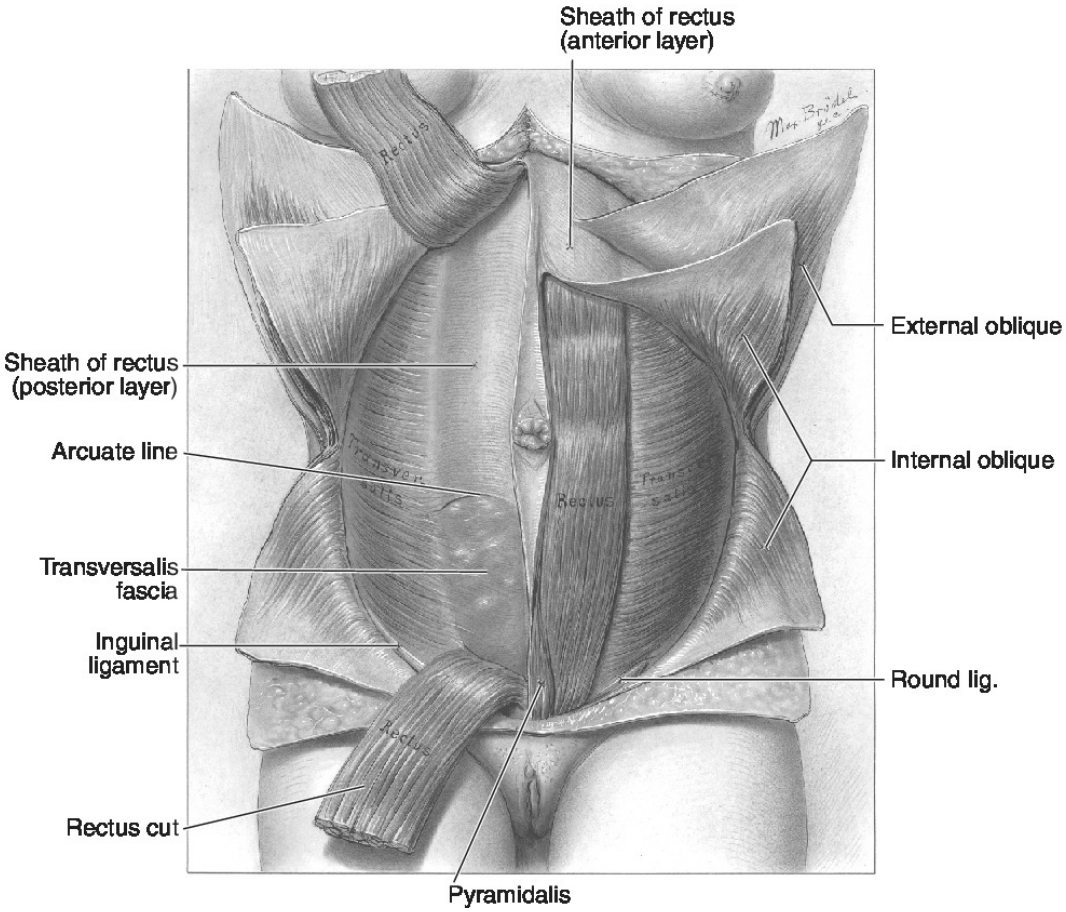


**FIGURE 1.2** Abdominal wall muscles and rectus sheath. (The original illustration is in the Max Brödel Archives in the Department of Art as Applied to Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA. Used with permission.)

## *Rectus Abdominis and Pyramidalis Muscles*

Each paired rectus abdominis muscle originates from the sternum and cartilages of ribs 5 through 7 and inserts into the anterior surface of the pubic bone. Each muscle has three to four tendinous

intersections or inscriptions. These are fibrous interruptions within the muscle that firmly attach it to the rectus abdominis sheath. In general, they are confined to the region above the umbilicus, but they can be found below it. At these fibrous interruptions, the rectus sheath is attached to the rectus muscle and thus the two structures are difficult to separate (eg, during a Pfannenstiel incision).

The pyramidalis muscles arise from the pubic bones anterior to the rectus abdominis and insert into the midline linea alba several centimeters above the symphysis. Their development varies considerably among individuals. Their strong attachment to the midline makes separation here difficult by blunt dissection.

# *Flank Muscles*

Lateral to the rectus abdominis muscles lie the broad, flat muscles of the flank. Their aponeurotic insertions join to form the rectus sheath, which covers the rectus abdominis muscles. Because of its importance, the rectus sheath is further discussed below.

The most superficial of these muscles is the external oblique. Its fibers run obliquely anteriorly and inferiorly from their proximal origin on the lower eight (5 through 12) ribs to the broad distal insertions of their aponeuroses on the iliac crest, pubic tubercle, and linea alba. The inferior margin of the external oblique aponeurosis is thickened, and its free posterior edge forms the inguinal ligament. The fibers of the internal oblique muscle fan out superiorly and medially from their origin in the anterior two-thirds of the iliac crest, the lateral part of the inguinal ligament, and the thoracolumbar fascia to their distal attachments on the inferior borders of ribs 10 through 12, the pecten pubis via the conjoint tendon, and the linea alba. In most areas, the fibers of the internal oblique are perpendicular to the fibers of the external oblique muscle; however, in the lower abdomen, the internal oblique fibers arch somewhat more caudally and run in a direction similar to those of the external oblique muscle.

As the name *transversus abdominis* implies, the fibers of the deepest of the three flat muscles have a primarily transverse orientation. They arise from the costal cartilages of the lower six (7 through 12) ribs, the thoracolumbar fascia, the iliac crest, and the

lateral third of the inguinal ligament. Their distal attachments are to the pubic crest, the pecten pubis via the conjoint tendon, and the linea alba. The caudal portion of the transversus abdominis muscle is fused with the internal oblique muscle to form the inguinal falx, also called the conjoint tendon. This fusion explains why, during transverse incisions of the lower abdomen, only two layers are discernible at the lateral portion of the incision. The aponeurotic fibers of the conjoint tendon attach to the pubic crest and pecten pubis. This tendon lies immediately behind the superficial inguinal ring, and along with the transversalis fascia, forms the posterior wall of the inguinal canal. A weakening of the conjoint tendon can lead to a direct inguinal hernia. The inferior free edge of the transversus abdominis and internal oblique muscle fibers form the superior boundary (roof) of the inguinal canal.

Although the fibers of the flank muscles are not strictly parallel to one another, their primarily transverse orientation and the transverse pull of their attached muscular fibers place vertical suture lines in the rectus sheath under more tension than transverse ones. For this reason, vertical incisions are more prone to dehiscence.

## *Rectus Sheath*

The muscle fibers of the external oblique become aponeurotic approximately at the midclavicular line. In the lower abdomen, this demarcation gradually develops more laterally (**FIG. 1.3**). At its inferior margin, the muscle fibers of the internal oblique extend farther toward the midline than do the muscle fibers of the external oblique. Because of this, fibers of the internal oblique muscle are found underneath the aponeurotic portion of the external oblique muscle during a low transverse incision (**FIG. 1.4**).

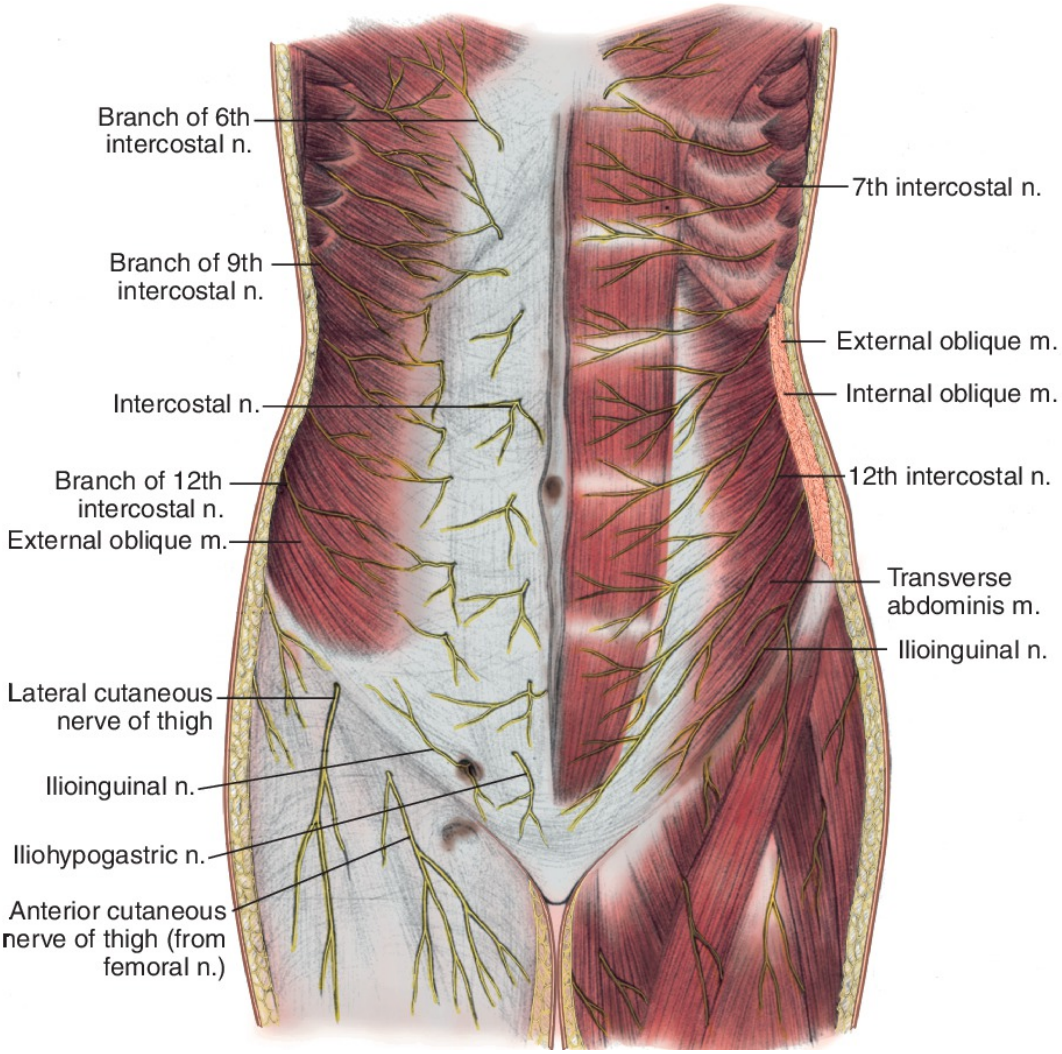


**FIGURE 1.3** Nerve supply to the abdominal wall. *Right*: Deep innervation to the transverse abdominis, internal oblique, and rectus muscles. *Left*: Superficial distribution, including cutaneous nerves, after penetration and innervation of the external oblique muscle and fascia. Innervation of the groin and thigh also is shown.

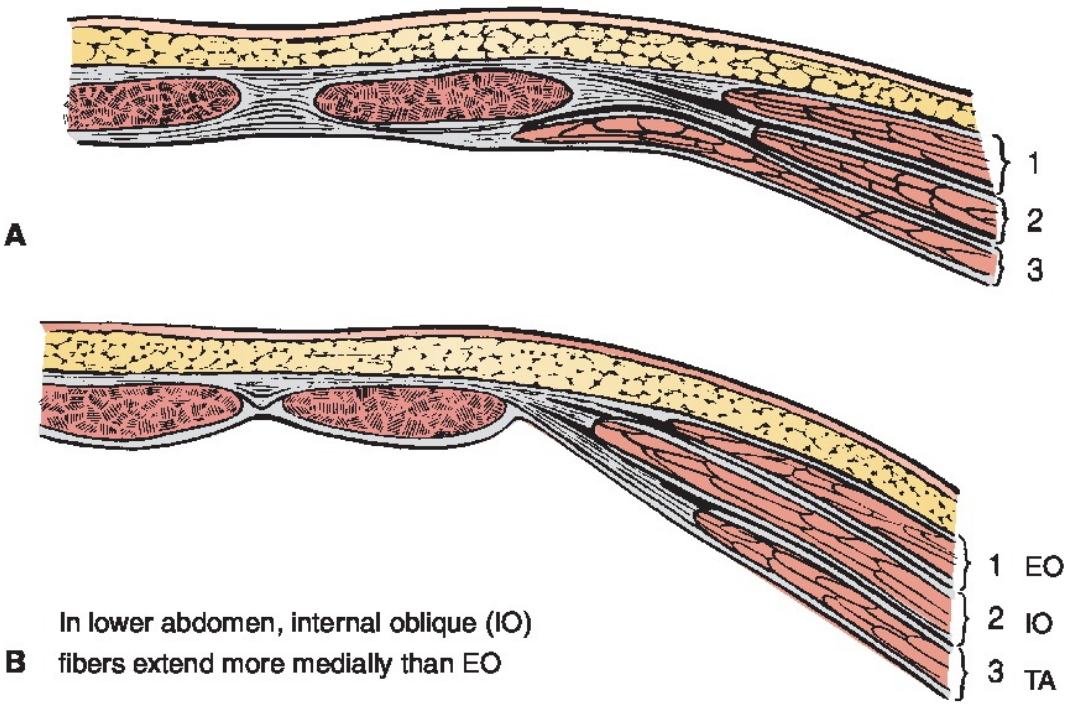


**FIGURE 1.4** Cross sections of lower abdominal wall above and below the arcuate line. *1*, External oblique; *2*, internal oblique; and *3*, transversus abdominis muscle. **A.** Above the arcuate line (linea semicircularis): the anterior fascial sheath of the rectus muscle (in *gray*) is derived from the external oblique and split aponeurosis of internal oblique muscles. The posterior sheath is formed by aponeurosis of the transversus abdominis muscle and split aponeurosis of the internal oblique muscle. **B.** Lower portion of the abdominal wall, below the arcuate line: the rectus muscle does not have a posterior fascial sheath, while all of the fascial

aponeuroses form the anterior rectus muscle sheath. The rectus muscle is in direct contact with the transversalis fascia.

In addition, between the internal oblique and transversus abdominis muscles lies a neurovascular plane, which corresponds to a similar plane in the intercostal spaces. This plane contains the nerves and arteries that supply the anterolateral abdominal wall. In the anterior part of the abdominal wall, these nerves and vessels exit the neurovascular plane and lie mostly in the subcutaneous tissue. Although not often possible, the nerves should be identified and spared, and strategies used to avoid injury within the neurovascular plane should be used. For example, low transverse fascial incisions often used for gynecologic surgery should not extend beyond lateral margins of rectus muscles to avoid nerve and inferior epigastric vessel injury. In addition, suture purchases that extend lateral to the edges of incision should be avoided as they may entrap the iliohypogastric and/or ilioinguinal nerve, which may lead to denervation injury or pain as described later (under ilioinguinal and iliohypogastric sections below).

Many specialized aspects of the rectus sheath are important to the surgeon (**FIG. 1.4**). In its lower one-fourth, the sheath lies entirely anterior to the rectus muscle. Above that point, it splits to lie both anterior and posterior to the rectus muscle, thus forming the anterior and posterior layers of the rectus sheath. The transition between these two arrangements occurs at the arcuate line, approximately one-third of the distance from the umbilicus to the pubic crest, which lies medial to the pubic tubercle. Superior to this line, the midline ridge of the rectus sheath, the linea alba, unites the anterior and posterior layers of the sheath. Sharp dissection is usually required to separate these layers in the midline during a Pfannenstiel incision. Below the arcuate line, the rectus abdominis muscles are in contact with the transversalis fascia. A vertical incision that extends to or above the umbilicus therefore requires incision of the posterior sheath.

The lateral border of the rectus muscle is marked by the linea semilunaris, a curved tendinous line that extends from the cartilage of the ninth rib to the pubic tubercle. It is formed by the internal oblique aponeurosis at its line of division to enclose the rectus muscle and is reinforced anteriorly by the external oblique and transversus abdominis aponeurosis. The linea semilunaris is not always where the three layers of flank muscles fuse: above the arcuate line, the internal oblique muscle aponeurosis splits to contribute to the anterior and posterior layers of the rectus sheath, while below the arcuate line, the transversalis fascia lies immediately posterior to the rectus muscles. During a transverse lower abdominal incision, the external and internal oblique aponeuroses are often separable near the midline. A hernia through the linea semilunaris is called a Spigelian hernia or lateral-ventral hernia.

The inguinal canal lies at the lower edge of the musculofascial layer of the abdominal wall. It is superior and parallel to the inguinal ligament. The midinguinal point is halfway between the pubic symphysis and the anterosuperior iliac spine. The femoral pulse can be palpated here. The inguinal canal has two openings, the superficial and deep inguinal rings. In the embryological stage, the canal is lined by an outpocketing of the peritoneum (processus vaginalis) and the abdominal musculature. Failure of the processus vaginalis to regress can lead to an indirect inguinal hernia, where the peritoneal sac or potentially loops of bowel enter the inguinal canal through the deep inguinal ring, lateral to the inferior epigastric vessels. Through the inguinal canal, in the woman, the round ligament extends to its termination in the labium majus. In addition, the ilioinguinal nerve and the genital branch of the genitofemoral nerve pass through the canal.

## *Transversalis Fascia, Peritoneum, and Bladder Reflection*

Deep to the muscular layers and superficial to the peritoneum lies the transversalis fascia, a layer of fibrous tissue that lines the abdominopelvic cavity. It is visible during abdominal incisions as the layer just underneath the rectus abdominis muscles suprapubically

(**FIG. 1.2**). It is separated from the peritoneum by a variable layer of extraperitoneal adipose tissue, sometimes called the preperitoneal fat. The transversalis fascia is frequently incised or bluntly dissected off the bladder to take the tissues in this region “down by layers.” This is the layer of tissue that is last penetrated to gain extraperitoneal entry into the retropubic space.

The peritoneum is a single layer of epithelial cells and supporting connective tissue called the serosa that lines the abdominal cavity and covers the abdominopelvic organs. The infraumbilical part of the anterolateral abdominal wall is characterized by five peritoneal folds (**FIG. 1.5**) that converge toward the umbilicus. The single median umbilical fold extends from the apex of the bladder to the umbilicus and covers the median umbilical ligament, a fibrous remnant of the urachus. Lateral to this are paired medial umbilical folds, which cover the medial umbilical ligaments, formed by the occluded part of the umbilical arteries. The lateral umbilical folds cover the inferior epigastric arteries and veins and, if transected, can lead to significant bleeding.

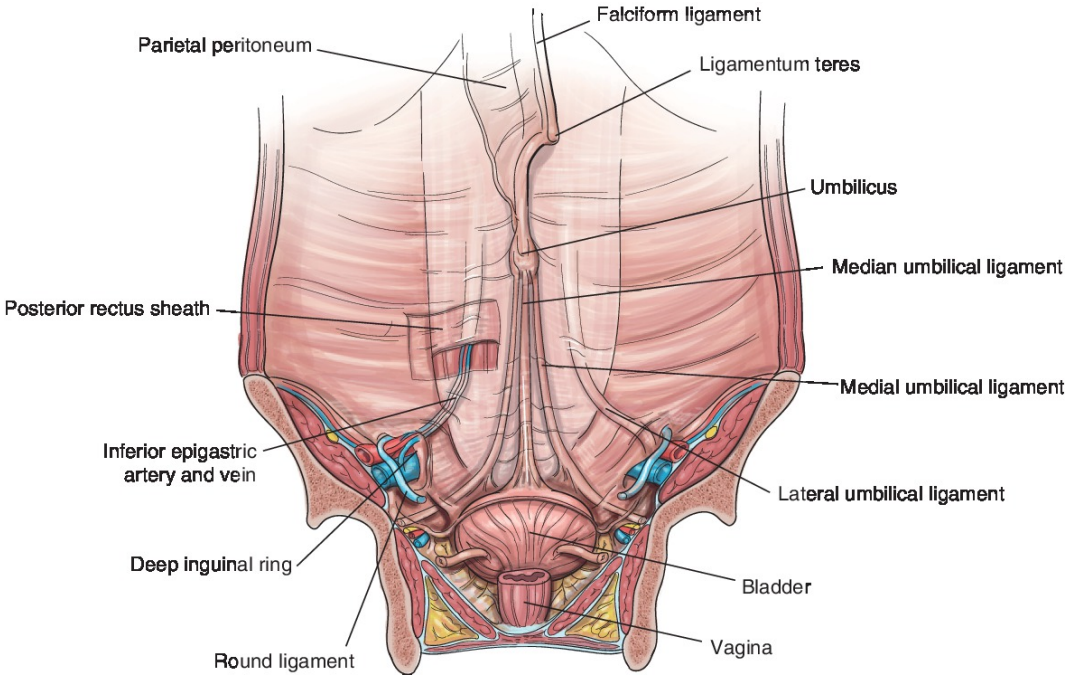

**FIGURE 1.5** Intraperitoneal view of anterior abdominal wall, demonstrating five peritoneal folds: the median umbilical fold (covering the median umbilical ligament), paired medial umbilical folds (covering the medial umbilical ligaments), and the lateral umbilical folds (covering the inferior epigastric arteries and veins). Note all umbilical peritoneal folds (ligaments) merge at the umbilicus.

The reflection of the bladder onto the abdominal wall is triangular in shape, with its apex blending into the median umbilical ligament. Because the apex is highest in the midline, incision in the peritoneum lateral to the midline is less likely to result in bladder injury.

## *Umbilical Area*

The umbilicus is an important surgical landmark and the most common point of entry during endoscopic surgery. All layers of the anterolateral abdominal wall fuse at the umbilicus (see **FIG. 1.5**). The umbilicus usually lies at a vertical level corresponding to the junction between the third and fourth lumbar vertebrae. This is also the level at which the iliac veins join to form the vena cava and at which the abdominal aorta bifurcates. The skin around the umbilicus is innervated by the 10th thoracic spinal nerve (T10 dermatome). The umbilicus contains the umbilical ring, a defect in the linea alba through which the fetal umbilical vessels passed to and from the umbilical cord and placenta. The umbilical ring provides a window through which umbilical hernias may develop. The round ligament of the liver and median umbilical and medial umbilical ligaments variably attach to the ring with inconsistent arrangements. The umbilical fascia is formed by a thickening in the transversalis fascia

behind the umbilicus, with possible contributions from the upward extension of the bladder visceral fascia (umbilicovesical fascia).

# Neurovascular Supply of the Abdominal Wall

## *Vessels of the Abdominal Wall*

Knowledge of the course of the abdominal wall blood vessels helps the surgeon anticipate their location during abdominal incisions or insertion of laparoscopic trocars (**FIG. 1.6**). The blood vessels that supply the abdominal wall can be separated into those that supply the skin and subcutaneous tissues and those that supply the musculofascial layer.

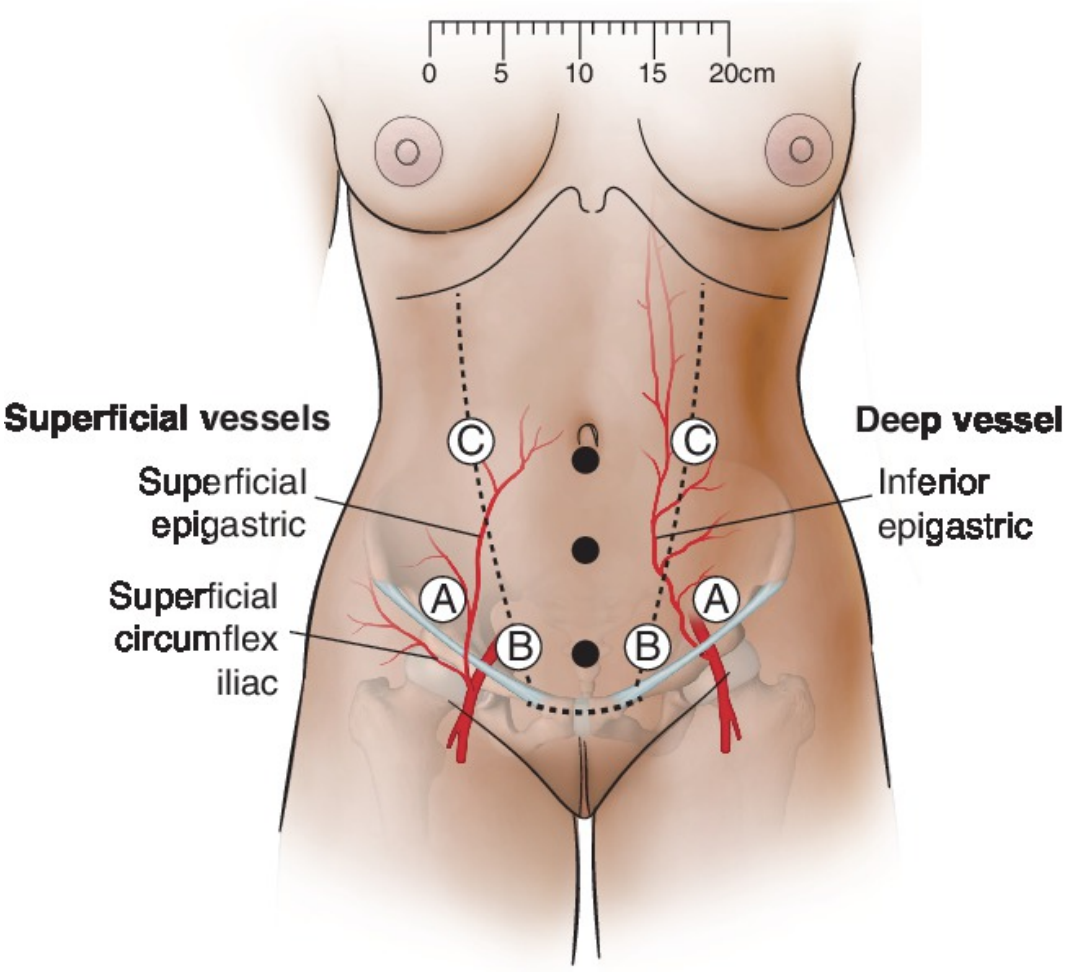


**FIGURE 1.6** Normal variation in epigastric vessels. *A*, *B*, and *C* designate safe spots for laparoscopic trocar insertion. *Dotted lines* indicate lateral border of the rectus muscle. (Redrawn from Hurd WW, Bude RO, DeLancey JOL, et al. The location of abdominal wall blood vessels in relationship to abdominal landmarks apparent at laparoscopy. *Am J Obstet Gynecol*. 1994;171(3):642-646.)

Three groups of vessels provide blood supply to the skin and subcutaneous tissues. The superficial epigastric vessels run a diagonal course in the subcutaneous tissue from the femoral vessels toward the umbilicus, beginning as a single artery that branches extensively as it nears the umbilicus. Its position can be anticipated midway between the skin and musculofascial layer, in a line between the palpable femoral pulse and the umbilicus. The external pudendal artery runs a diagonal course medially from the femoral artery to supply the region of the mons pubis. It has many midline branches, and bleeding in its territory of distribution is heavier than that from the abdominal subcutaneous tissues. The superficial circumflex iliac vessels course laterally from the femoral vessels toward the flank.

The blood supply to the lower abdominal wall's deeper musculofascial layer parallels the subcutaneous vessels. The inferior epigastric and the deep circumflex iliac arteries branch from the external iliac, and their course parallels that of their superficial counterparts (see **FIG. 1.6**). The deep circumflex iliac artery lies between the internal oblique and transversus abdominis muscle. The inferior epigastric artery and its two veins originate lateral to the rectus muscle. They run diagonally toward the umbilicus and intersect the muscle's lateral border midway between the pubis and umbilicus. Below the point at which the vessels pass under the rectus, they are found lateral to the muscle and deep to the transversalis fascia. After crossing the lateral border of the rectus muscle, they lie on the muscle's dorsal surface, between it and the posterior rectus sheath. As the vessels enter the rectus sheath, they branch extensively, so that they no longer represent a single trunk. The angle between the inferior epigastric vessels and the lateral border of the rectus muscle forms the apex of the inguinal triangle (Hesselbach triangle), the base of which is the inguinal ligament. This triangle represents the area through which direct inguinal hernias protrude medial to the inferior epigastric vessels. Around the umbilical area, the inferior epigastric artery anastomoses with the superior epigastric, a branch of the internal thoracic artery.

Lateral laparoscopic trocars are placed in a region of the lower abdomen where injury to the inferior epigastric and superficial epigastric vessels can easily occur. The inferior epigastric arteries

and the superficial epigastric arteries run similar courses toward the umbilicus. Knowing the typical location of these blood vessels helps in choosing insertion sites that will minimize their injury, reducing the potential for hemorrhage and hematomas. Just above the pubic symphysis, the vessels lie ~5.5 cm from the midline, whereas at the level of the umbilicus, they are 4.5 cm from the midline (see **FIG. 1.6**). Therefore, placement either lateral or medial to the line connecting these points minimizes potential vascular injury. In addition, the location of the inferior epigastric vessels can often be directly seen through the peritoneal layer laparoscopically (see **FIG. 1.5**), and during laparoscopic procedures, the superficial epigastric vessels can often be identified in thin patients by transillumination. The round ligament is traced to its point of entry into the deep inguinal ring, recognizing that the vessels lie just medial to this point (**FIG. 1.7**).

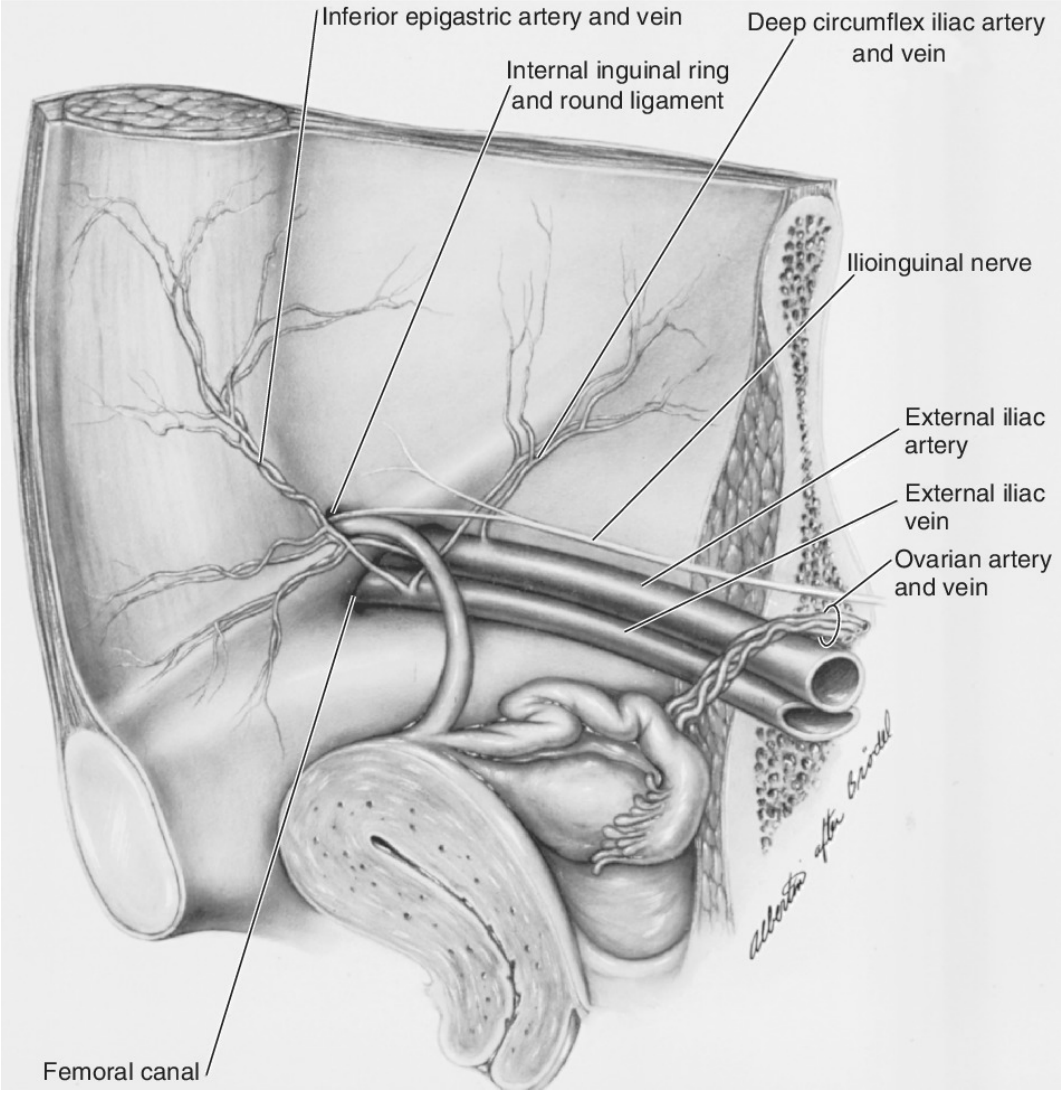


**FIGURE 1.7** Sagittal view of female pelvis, showing inguinal anatomy. Note that the inferior epigastric artery and vein lie just medial to the round ligament as it enters the deep inguinal ring. (The original illustration is in the Max Brödel Archives in the Department of Art as Applied to Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA. Used with permission.)

# *Nerves of the Abdominal Wall*

The innervation of the abdominal wall (see **FIG. 1.3**) arises from the abdominal extension of intercostal nerves 7 through 11, subcostal nerve (T12), and iliohypogastric and ilioinguinal nerves (both L1). Dermatome T10 lies at the umbilicus.

The cutaneous sensory innervation of the abdominal wall is derived from the intercostal nerves and the iliohypogastric and ilioinguinal nerves. After giving off a lateral abdominal cutaneous branch, each intercostal nerve pierces the lateral border of the rectus sheath. There it provides a lateral branch that ends in the rectus muscle. This branch then passes through the muscle and perforates the rectus sheath to supply the subcutaneous tissues and skin as anterior abdominal cutaneous branches. Incisions along the lateral border of the rectus lead to denervation of the muscle, which can render it atrophic and weaken the abdominal wall. Elevation of the rectus sheath off the muscle during the Pfannenstiel incision stretches the perforating nerve, which is sometimes ligated or cauterized to provide hemostasis from the accompanying artery. This may leave an area of cutaneous anesthesia.

The iliohypogastric and ilioinguinal nerves (**FIG. 1.8**) pass medial to the anterosuperior iliac spine in the abdominal wall. The former supplies the skin of the suprapubic area. The latter supplies the lower abdominal wall, and by sending a branch through the inguinal canal, it supplies the upper portions of the labia majora (anterior labial nerves) and medial portions of the thigh. The ilioinguinal and iliohypogastric nerves can be entrapped or cut during closure of a transverse incision or insertion of accessory trocars in the lower abdomen. This may lead to chronic pain syndromes that may manifest months to years after surgery. The risk of iliohypogastric and ilioinguinal nerve injury can be minimized if lateral trocars are placed superior to the anterosuperior iliac spines and if low transverse fascial incisions are not extended beyond the lateral borders of the rectus muscles.

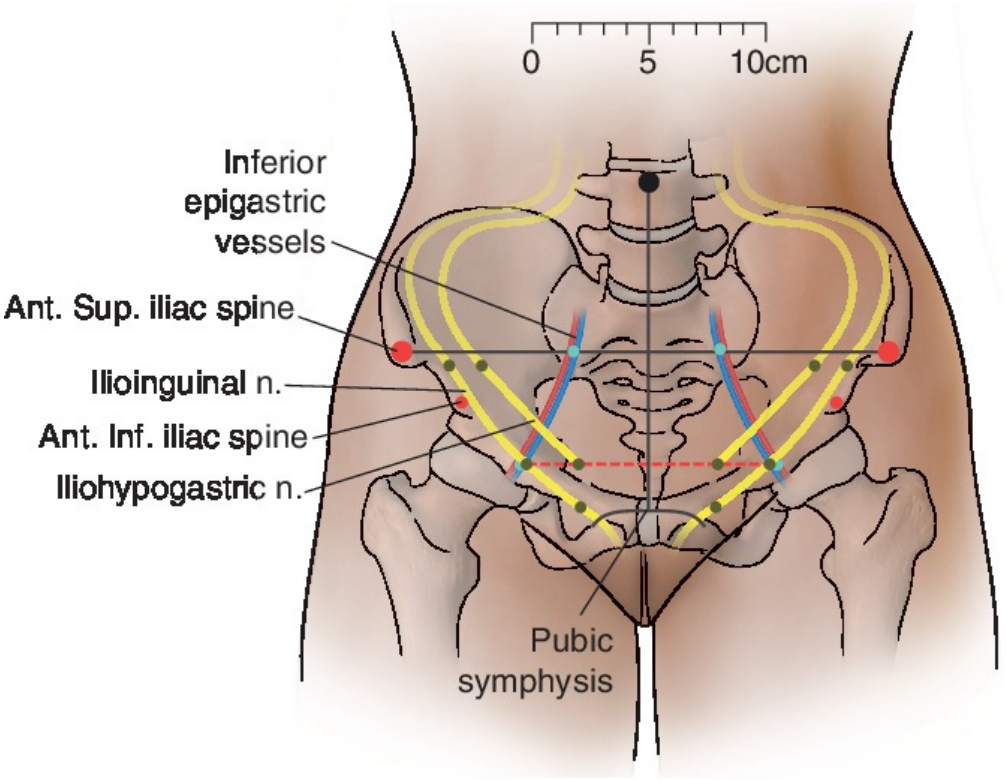


**FIGURE 1.8** Nerve and vessel locations on anterior abdominal wall relative to surgically important landmarks. (Redrawn from Rahn DD, Phelan JN, Roshanravan SM, et al. Anterior abdominal wall nerve and vessel anatomy: clinical implications for gynecologic surgery. *Am J Obstet Gynecol*. 2010;202(3):234.e1-234.e5.)

## Other Lumbar Plexus Branches

The genitofemoral nerve (L1 and L2) and lateral cutaneous nerve of the thigh (L2 and L3) can be injured during gynecologic surgery. The genitofemoral nerve lies on the anterior surface of the psoas muscle

(**FIG. 1.9**), where pressure from a retractor can damage it and lead to anesthesia in the medial thigh and lateral labia. This nerve can also be injured during pelvic lymphadenectomy and ureteral reimplantation with psoas hitch. The lateral cutaneous nerve courses over the iliacus muscle and passes under the inguinal ligament just medial to the anterosuperior iliac spine. It can be compressed either by a retractor blade lateral to the psoas or by excessive flexion of the hip in the lithotomy position, causing anesthesia over the anterior and lateral thigh. Meralgia paresthetica is a term often used when pain is also present.

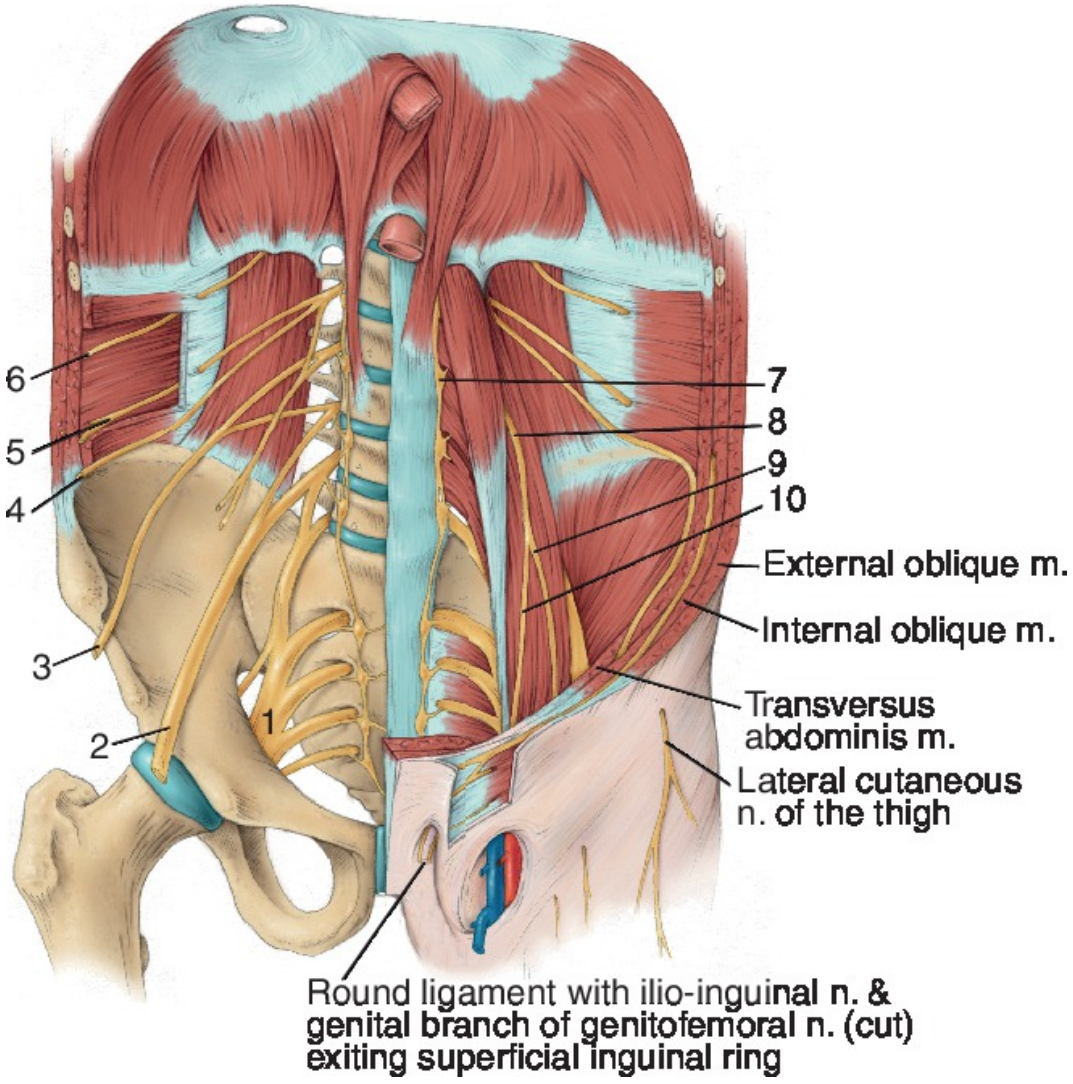

**FIGURE 1.9** Nerves of the lumbar plexus: *1*, sciatic nerve; *2*, femoral nerve; *3*, lateral cutaneous nerve of the thigh; *4*, ilioinguinal nerve; *5*, iliohypogastric nerve; *6*, subcostal nerve; *7*, sympathetic trunk and ganglion; *8*, genitofemoral nerve; *9*, femoral branch of genitofemoral nerve; and *10*, genital branch of genitofemoral nerve. (Reprinted with permission from Bigeleisen PE, Gofeld M, Orebaugh SL. *Ultrasound-Guided Regional Anesthesia and Pain Medicine*. 2nd ed. Wolters Kluwer; 2015. Figure 35.9.)

The largest branch of the lumbar plexus, the femoral nerve (L2-L4) can also be injured during gynecologic surgery. In the greater (false) pelvis, it emerges from the inferolateral surface of the psoas muscles (see **FIG. 1.9**). It then passes under the inguinal ligament to provide innervation to the anterior thigh compartment muscles and sensation to the anterior thigh and medial leg (**FIG. 1.10**). Femoral nerve injury during abdominal procedures can result from nerve compression by the lateral blades of retractors. During vaginal surgery, femoral nerve injury is most often attributed to lithotomy positioning. The nerve can be compressed against the inguinal ligament with thigh hyperflexion (see Chapter 5) or with excessive hip abduction and/or lateral rotation. Clinical manifestations of femoral nerve injury may include difficulty or inability to flex the thigh and extend the knee, absent patellar reflexes, and sensory loss over the anterior thigh and medial aspect of the leg.

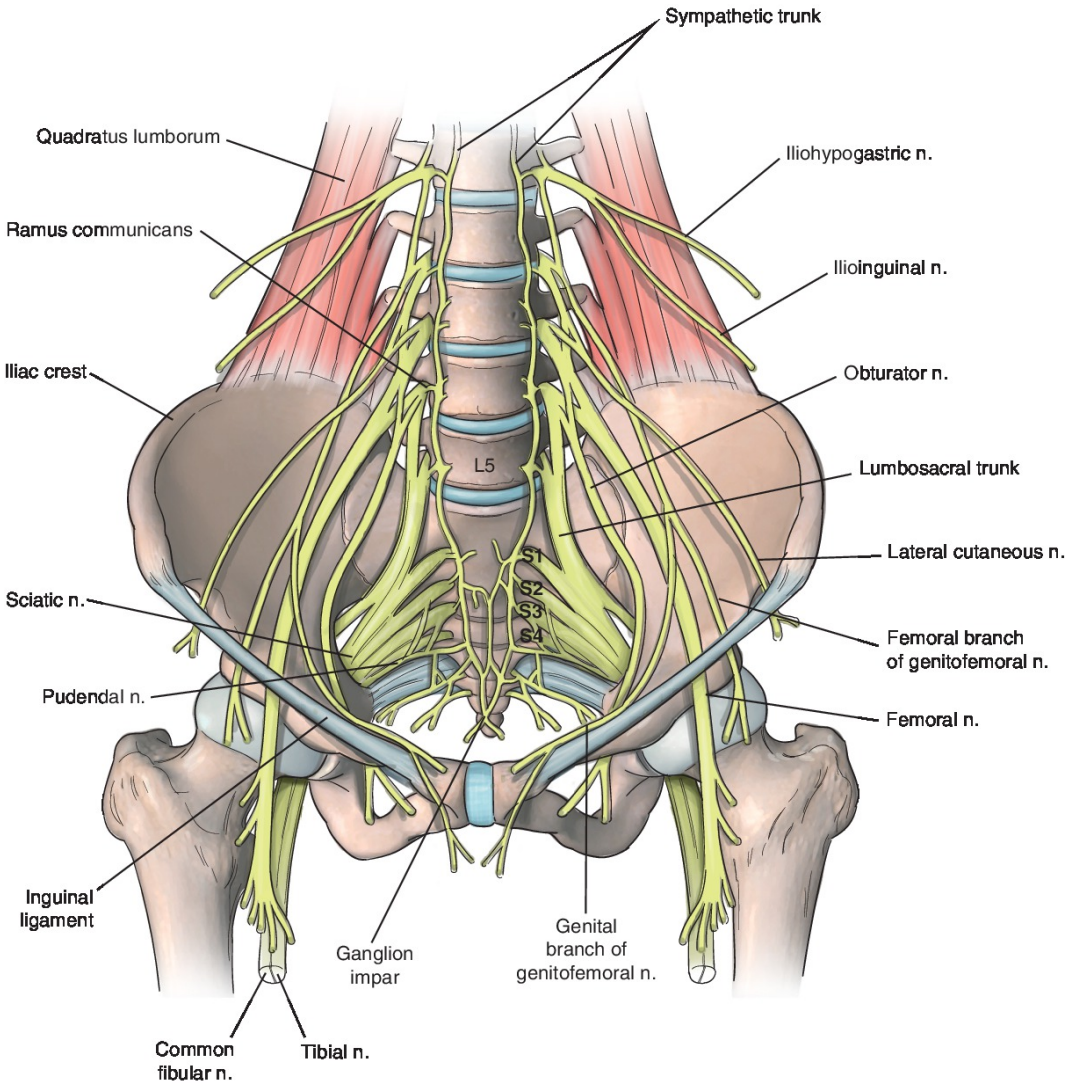


**FIGURE 1.10** Nerves of the lumbosacral plexus: note that several branches (femoral nerve, lateral cutaneous nerve of the thigh, and femoral branch of genitofemoral nerve) pass under inguinal ligament and can be compressed in lithotomy. (Reprinted with permission from Agur AM, Dalley AF. *Grant's Atlas of Anatomy*. 14th ed. Wolters Kluwer; 2016. Figure 4.78.)

The obturator nerve (L2-L4) is the only branch of the lumbar plexus that courses through the lesser (true) pelvis (**FIG. 1.11**). It exits through the obturator canal and enters the thigh to supply the adductor muscles and skin over the medial thigh. The obturator nerve may be injured during pelvic lymphadenectomies or incontinence or pelvic support procedures where the retropubic space or the thigh compartment is entered. Clinical manifestations of obturator nerve injury include difficulty or inability adducting the thigh and sensory loss over the inner thigh. If obturator nerve transection is recognized intraoperatively, appropriate surgical consultation is warranted as microsurgical reapproximation can result in almost complete recovery of motor function.

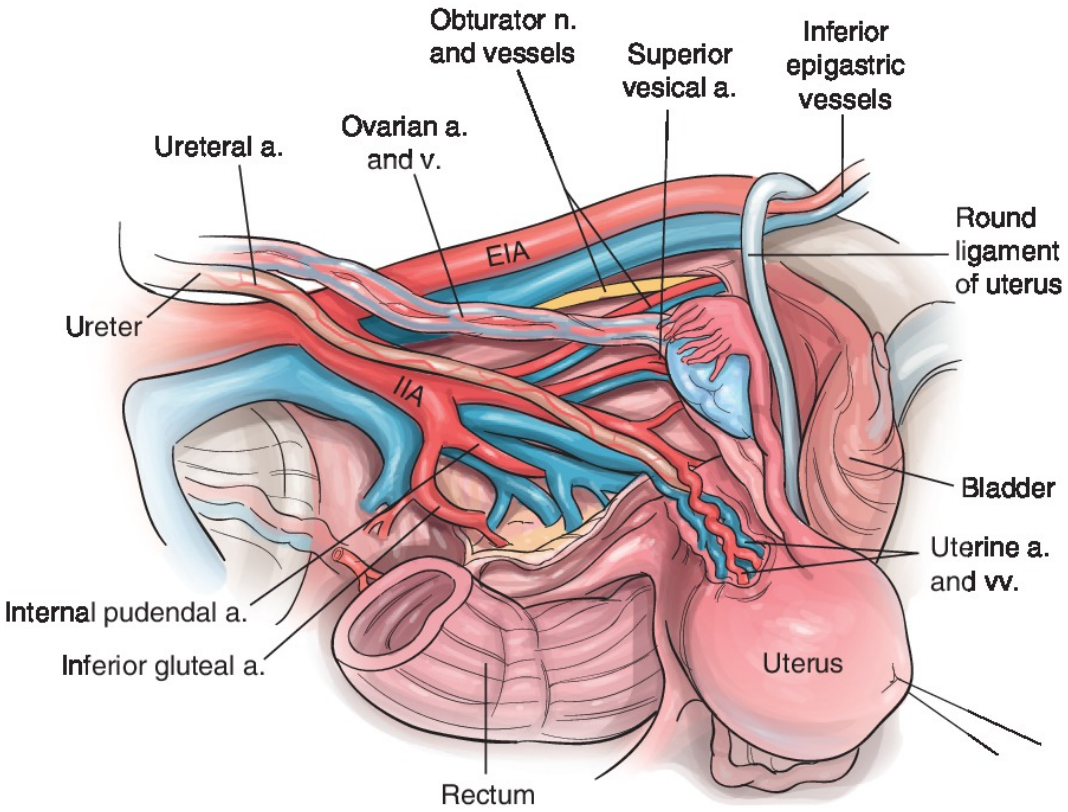


**FIGURE 1.11** Arteries and veins of the pelvis. The obturator nerve and vessels exit the pelvis via the obturator canal.

# VULVA AND ERECTILE STRUCTURES

The pudendum or vulva is part of the female external genitalia and is found on the superficial pouch of the anterior perineal triangle (**FIGS. 1.12-1.14**). The perineum can be divided into anterior and posterior triangles, which share a common base along a line between the ischial tuberosities (see **FIG. 1.13**). The outer boundaries of these triangles are those of the bony pelvic outlet: the pubic arch and ischiopubic rami anterolaterally and the sacrotuberous ligament and coccyx posterolaterally. The tissues filling the anterior triangle (**TABLE 1.2**) have a layered structure similar to that of the abdominal wall. More specifically, there is a skin and subcutaneous tissue overlying a fascial layer (perineal membrane). The superior boundary of both anterior and posterior perineal triangles is the inferior fascia of the levator ani muscles.

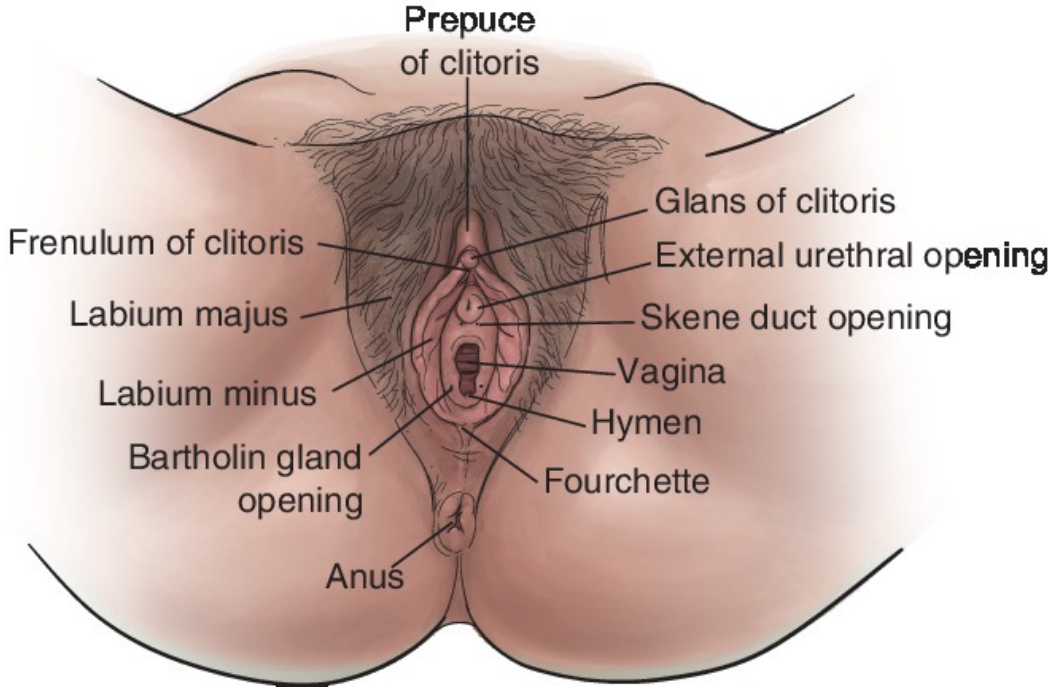


**FIGURE 1.12** External genitalia.

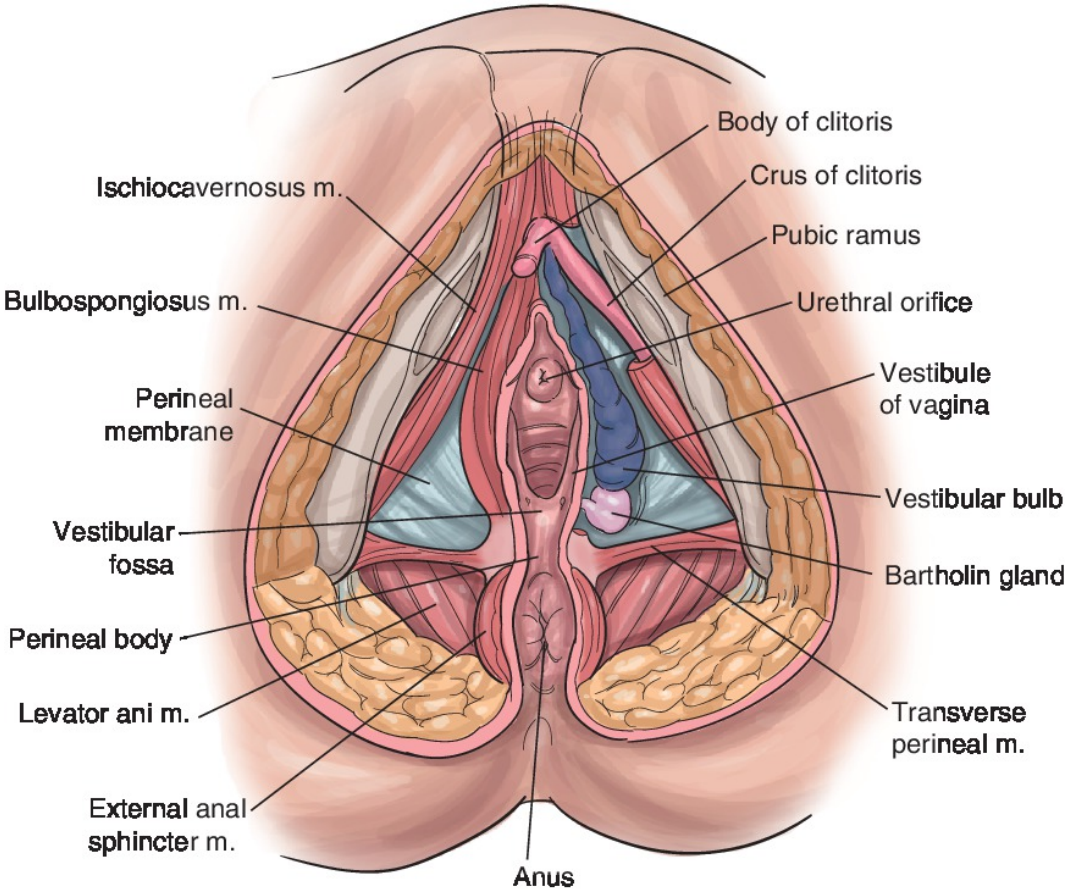


**FIGURE 1.13** Anterior and posterior perineal triangles. Structures within the superficial compartment of the anterior triangle and their relationship to perineal membrane are shown.

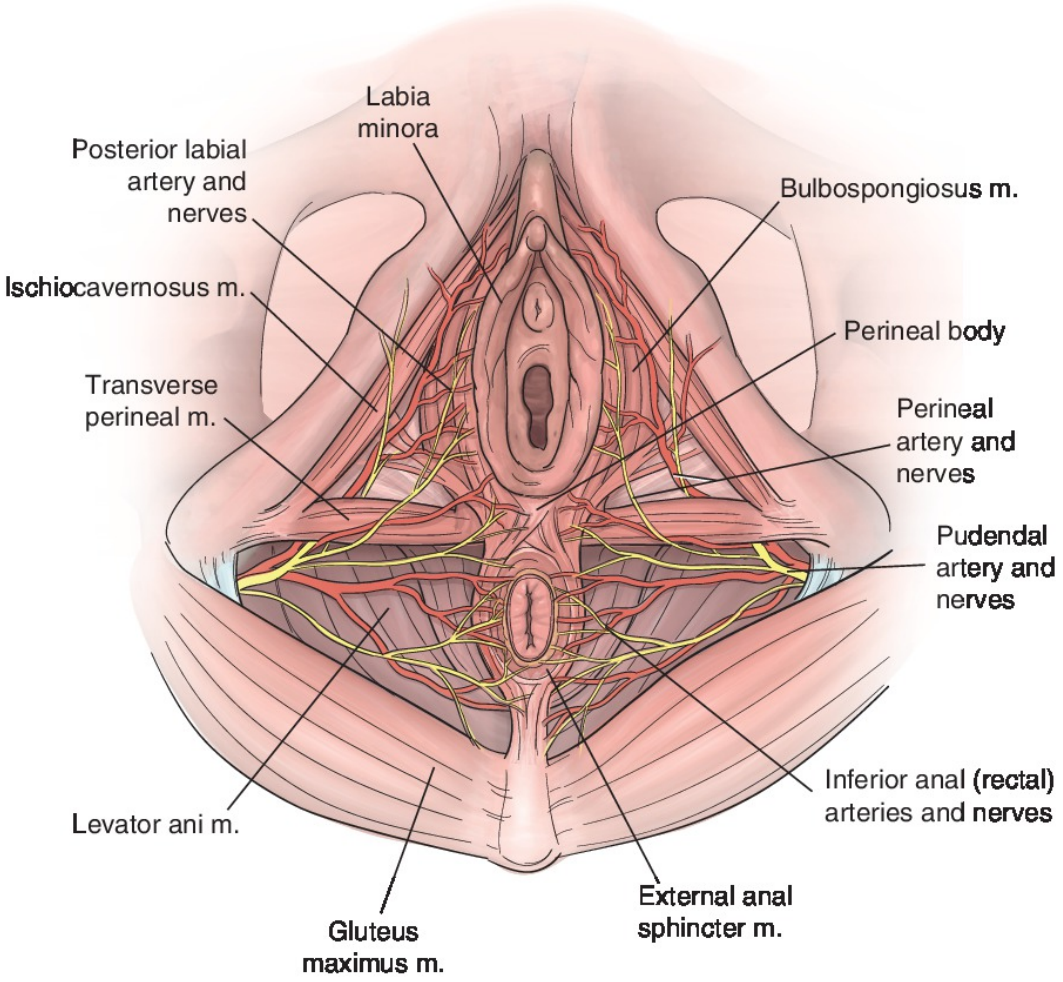


**FIGURE 1.14** Pudendal nerve and vessels.

## TABLE 1.2
## Layers and Pouches of the Anterior Triangle of the Perineum

| NERVE | ROOT | FIBER TYPE | INNERVATION | SYMPTOMS | VULNERABILITY |
|---|---|---|---|---|---|
| Ulnar | C8-T1 | Afferent<br>Efferent | Forearm flexors<br>Intrinsic hand muscles for flexion, abduction, and adduction of the finger<br>Sensation to medial 1.5 fingers | Weakened finger abduction and adduction<br>Claw hand<br>Unable to make a fist<br>Hypoesthesia and paresthesia of the medial 1.5 finger | Compression against the arm board or operating table |
| Median | C6-C8, T1 | Afferent<br>Efferent | Anterior forearm<br>Intrinsic hand muscles—thumb and lateral 2 fingers | Weak flexion of the wrist and finger<br>Weak thumb<br>Inability to make "O" with thumb and index finger<br>Hypoesthesia of the thumb and lateral 2.5 finger | Hyperextension of elbow on arm board |
| Radial | C5-T1 | Afferent<br>Efferent | Forearm extensors<br>Posterior arm<br>Sensation to posterior aspect of lateral 3.5 fingers | Weakness when abducting the thumb, inability to straighten fingers, wrist drop<br>Hypoesthesia of dorsal lateral 3.5 digits | Pressure on the humerus |

# Subcutaneous Tissues of the Vulva

The structures of the vulva lie on the pubic bones and extend posteriorly under the pubic arch (**FIG. 1.12**). They consist of the mons, labia, vestibule, clitoris, and associated erectile structures and their muscles. The mons consists of hair-bearing skin over a cushion of adipose tissue that lies on the pubic bones. Extending posteriorly from the mons, the labia majora are composed of similar hair-bearing skin and adipose tissue, which contain the termination of the round ligaments of the uterus and the obliterated vaginal process (canal of Nuck). The round ligament can give rise to leiomyomas in this region, and the obliterated vaginal process can be a dilated embryonic remnant in the adult. Incomplete obliteration of the canal can result in an indirect inguinal hernia or a hydrocele, which are rare conditions in women. Anterior to the pudendal cleft and below the mons, each labium majus joins to form the anterior commissure of the labia majora. The posterior commissure represents the anterior or upper part of the perineal body skin.

The labia minora, vestibule, and glans of the clitoris can be seen between the two labia majora. The labia minora are hairless skin folds, each of which splits anteriorly to run over, and under, the glans of the clitoris. The more anterior folds unite to form the distal end of the prepuce of the clitoris, which partially or completely covers the glans of the clitoris and is often called the hood of the clitoris; the posterior folds insert into the underside of the glans as the frenulum

of the clitoris. Posteriorly, the labia minora join in the midline to form the frenulum of labia minora or fourchette.

Unlike the skin of the labia majora, the cutaneous structures of the labia minora and vestibule do not lie on an adipose layer but on a connective tissue stratum that is loosely organized and permits mobility of the skin during intercourse. This loose attachment of the skin to underlying tissues allows the skin to be easily dissected off the underlying tissue during skinning vulvectomy in the area of the labia minora and vestibule. The labia minora are highly sensitive structures that lie in close proximity to the clitoris and vestibular bulbs. Clinically, great variation exists in shape and size of the labia minora. In some women, one or both labia may markedly extend beyond the labia majora and can be drawn into the vagina during coitus or other activities. If associated with dyspareunia or pain in these settings, the labia minora can be surgically reduced. Among others, complications such as hypoesthesia and paresthesias may develop following labial reduction procedures, given the vast sensory innervation to these structures. Moreover, chronic dermatologic diseases such as lichen sclerosus may lead to significant atrophy or disappearance of the labia minora. Surgical procedures that involve removal of the prepuce or adjacent skin and underlying connective tissue may lead to injury of the dorsal nerve of the clitoris. The path of this nerve will be discussed later with other terminal pudendal nerve branches.

In the posterolateral aspect of the vestibule, the duct of the greater vestibular (Bartholin) gland can be seen 3-4 mm outside the hymen or hymenal caruncles at the hymenal ring. The lesser vestibular gland openings are found along a line extending anteriorly from this point, parallel to the hymenal ring, and extending toward the external urethral orifice. More anteriorly, the urethra protrudes slightly beyond the surrounding vestibular skin, anterior to the vagina, and posterior to the clitoris. Its orifice is flanked on either side by two small folds. The openings of the most distal of the paraurethral glands, often called Skene ducts, open into the inner aspect of these folds and can be seen as small, punctate openings when the external urethral orifice is exposed.

Within the skin of the vulva are specialized glands that can become enlarged and thereby require surgical removal. The holocrine sebaceous glands are associated with hair shafts in the labia majora; in the labia minora, they are freestanding. They lie close to the surface, which explains their easy recognition with minimal enlargement. In addition, lateral to the introitus and anus, there are numerous apocrine sweat glands, along with the normal eccrine sweat glands. The former structures undergo change with the menstrual cycle, having increased secretory activity in the premenstrual period. They can become chronically infected, as in hidradenitis suppurativa, or neoplastically enlarged, as in hidradenomas, both of which may require surgical therapy. The eccrine sweat glands in the vulvar skin rarely present abnormalities, but on occasion form palpable masses as syringomas.

The subcutaneous tissue of the labia majora is similar in composition to that of the abdominal wall. It consists of lobules of fat interlaced with connective tissue septa. Although there are no well-defined layers in the subcutaneous tissue, regional variations in the relative quantity of fat and fibrous tissue exist. The superficial region of this tissue, where fat predominates, is the fatty layer, as it is on the abdomen. In this region, there is a continuation of fat from the anterior abdominal wall that contains smooth muscle and the termination of the round ligament of the uterus; this tissue is called a finger-shaped process of fat.

In the deeper layers of the vulva, there is less fat, and the interlacing fibrous connective tissue septa are much more evident than those in the fatty layer. As it is in the abdomen, this more fibrous layer is called the membranous layer (previously Colles fascia) and is similar to the membranous layer (Scarpa fascia) on the abdomen. The membranous layer attachments or the attachments of the membranous layer to other structures have clinical significance. The interlacing fibrous septa of the subcutaneous tissue attach laterally to the ischiopubic rami and fuse posteriorly with the posterior edge of the perineal membrane (previously urogenital diaphragm). Anteriorly, however, there is no connection to the pubic rami, and this permits communication between the area deep to this layer and the abdominal wall. These fibrous attachments to the

ischiopubic rami and the posterior aspect of the perineal membrane limit the spread of hematomas or infection deep to the membranous layer posterolaterally but allow spread into the abdomen. This clinical observation has led to the consideration of the membranous layer as a separate entity from the superficial fatty layer, which lacks these connections. Spread of hematomas or infection from the subcutaneous layer of the abdomen to the corresponding layer of the perineum is also possible. Extravasation of carbon dioxide into the subcutaneous layer, as can occur during laparoscopy (either with accidental trocar displacement or with lengthy procedures), can lead to subcutaneous emphysema that extends from the subcutaneous tissue of the abdominal wall to the subcutaneous layer of the perineum.

# Superficial Compartment

The space between the superficial layer of investing fascia of perineal muscles and perineal membrane, which contains the clitoris, crura, vestibular bulbs, and ischiocavernosus and bulbospongiosus muscles, is called the superficial perineal pouch or compartment (see **FIG. 1.13**). The deep compartment is the region just deep to the perineal membrane; it is discussed later.

The erectile bodies (body and crura of the clitoris and bulb of the vestibule) and their associated muscles within the superficial compartment lie on the caudal surface of the perineal membrane. The clitoris is a complex erectile and highly sensitive organ, which is homologous to the penis. It is embryologically derived from the genital tubercle. In contrast to the penis, the clitoris is not functionally related to the urethra, and thus, its primary function is in sexual arousal and orgasm. It is composed of a midline body, topped with the glans, and paired crura. The body lies on, and is suspended from, the pubic bones by the subcutaneous suspensory and fundiform ligaments of the clitoris. The fundiform ligament of the clitoris is fibrous condensation of the subcutaneous tissue descending from the linea alba above the pubic symphysis, which splits and surrounds the body of the clitoris, before fusing with the fascia of the clitoris. Along with the suspensory ligament, it

contributes to the support and positioning of the clitoral body. The paired crura of the clitoris bend downward from the body and are firmly attached to the pubic bones, continuing dorsally to lie on the inferior aspects of the ischiopubic rami. They join in midline to form the body of the clitoris. The body of the clitoris consists of paired corpora cavernosa separated in midline by a fibrous septum, appropriately called the septum of corpora cavernosa. Both the corpora cavernosa and the paired crura are invested by a layer of fibroconnective tissue called the tunica albuginea. The dorsal nerve and vessels of the clitoris, discussed later, lie outside the tunica albuginea but within the clitoral fascia, which is continuous with the deep portion of the suspensory ligament of the clitoris. The ischiocavernosus muscles originate at the ischial tuberosities and the free surfaces of the crura to insert on the upper crura and often on the body of the clitoris. A few muscle fibers, called the superficial transverse perineal muscles, originate in common with the ischiocavernosus muscle from the ischial tuberosity and course transversely toward the lateral margins of the perineal body.

The paired vestibular bulbs are elongated 3- to 4-cm masses of richly vascular spongy erectile tissue that lie immediately under the vestibular skin. They overlie the greater vestibular (Bartholin) glands posteriorly, and the bulb from each side joins anteriorly at the commissure of the bulbs, where the spongy tissue attaches to the undersurface of the glans and body of the clitoris. The bulbs are partially covered by the bulbospongiosus muscles, which originate in the perineal body. These muscles, along with the ischiocavernosus muscles, insert into the body of the clitoris and act to pull it downward. All muscles in the superficial perineal triangle, bulbospongiosus, ischiocavernosus, and superficial transverse perineal are covered by a layer of fascia called the perineal fascia, which is continuous with the clitoral fascia.

The greater vestibular (Bartholin) gland is found at the tail end of the bulb of the vestibule and is connected to the vestibular mucosa by a duct lined with squamous epithelium. The gland lies on the perineal membrane and beneath the bulbospongiosus muscle (previously referred to as bulbocavernosus). The intimate relation between the enormously vascular tissue of the vestibular bulb and

the Bartholin gland is responsible for the risk of hemorrhage associated with removal of this latter structure.

The perineal membrane and perineal body are important to the support of the pelvic organs. They are discussed in the section on the pelvic floor.

# Pudendal Nerve and Vessels

The pudendal nerve is the main sensory and motor nerve of the perineum. Its course and distribution in the perineum parallel the internal pudendal artery and veins that connect with the internal iliac vessels (see **FIG. 1.14**). The course and division of the nerve are described with the understanding that the vascular channels parallel them.

The pudendal nerve arises from the sacral plexus (S2-S4), and the associated arteries originate from the anterior division of the internal iliac artery. They leave the pelvis through the greater sciatic foramen by passing behind the sacrospinous ligament, just medial to the ischial spine (**FIG. 1.15**). They then enter the pudendal (Alcock) canal through the lesser sciatic foramen. The pudendal canal is formed by a splitting of the obturator fascia covering the medial surface of the obturator internus muscle. It roughly expands from the ischial spine proximally to the ischial tuberosity distally.

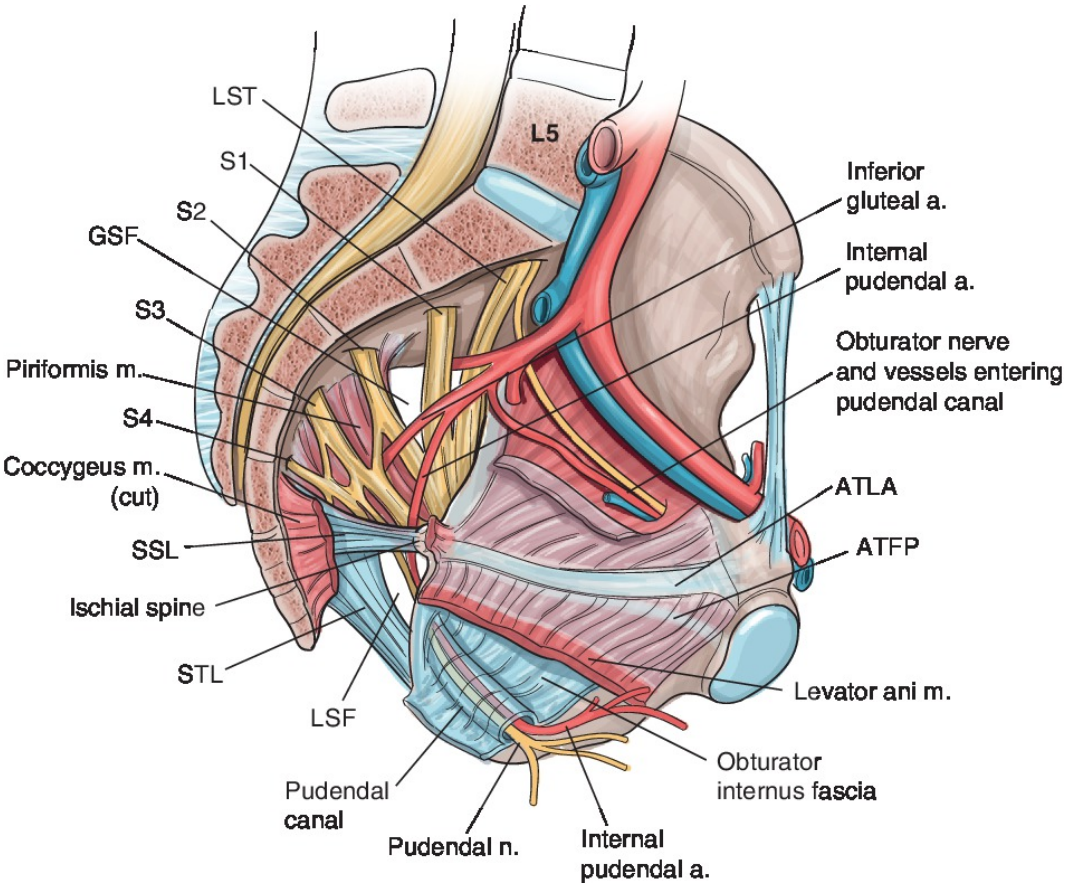


**FIGURE 1.15** Course of pudendal nerve (n) and vessels in the pelvis and in the pudendal canal. LSF, lesser sciatic foramen; SSL, sacrospinous ligament; STL, sacrotuberous ligament.

The nerve and vessels have three branches: the clitoral, perineal, and inferior rectal. The course and distribution of each nerve branch is described below with the understanding that vessels follow a similar path.

## Terminal Branches of Pudendal Nerve

The three terminal branches of the pudendal nerve are the dorsal nerve of clitoris, perineal nerve, and inferior anal (rectal) nerves.

These nerves provide sensation to the external female genitalia and motor innervation to the superficial perineal muscles, parts of the striated urethral sphincter muscles, and external anal sphincter muscle.

*Dorsal nerve of the clitoris*. This nerve is the primarily sensory nerve to the clitoris (**FIG. 1.16**). After exiting the pudendal canal, this nerve remains within the deep pouch of the anterior perineal triangle firmly adherent to the inner surface of the ischiopubic ramus. It perforates the perineal membrane adjacent to the medial surface of the ramus to reach the superficial perineal pouch. Here, it courses on the deep surface of the ischiocavernosus muscle and clitoral crus. In this region, the nerve is surrounded by a dense fibrous capsule adherent to the periosteum of the ischiopubic ramus. Approximately 2-3 cm lateral to the mid pubic symphysis, it emerges from the deep and lateral surface of the crus and then courses toward the dorsal surface of the clitoral body tightly embedded in layers of fibroconnective tissue, including that of the suspensory and fundiform ligaments of the clitoris. In this region, the nerve is consistently 2-4 mm in diameter. The nerve from each side then courses along the dorsal surface of the clitoral body, at approximately the 11 o'clock and 1 o'clock positions. It remains deep to the clitoral fascia but superficial to the tunica albuginea layer that surrounds the corpora cavernosa. In this area, it gives off small branches to the skin of the prepuce and to the corpora cavernosa. It ends by perforating the glans of the clitoris to which it provides sensory innervation. The section of this nerve that courses deep within the suspensory ligament is covered by vulvar and prepuce skin as well as by their underlying layer of connective tissue. Thus, excisional procedures that extend deep to the subcutaneous tissue in this region, pelvic fractures, and some anti-incontinence procedures risk injury to this nerve and can affect clitoral sensation and sexual function.

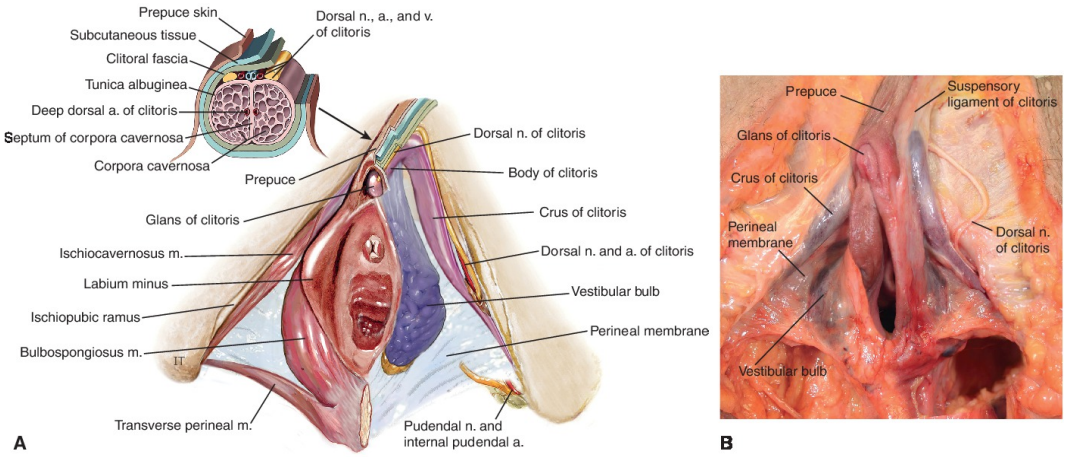


**FIGURE 1.16 A, B.** Clitoral anatomy, including the dorsal nerve of the clitoris. (Illustration by Elizabeth Han.)

*Perineal nerve* (see **FIG. 1.14**). The perineal nerve is the largest branch of the pudendal nerve. Branches of this nerve include the posterior labial nerves, which supply the labia minora and all but the anterior part of the labia majora; muscular branches, which provide motor innervation to the muscles of the superficial perineal pouch (ischiocavernosus, bulbospongiosus, and superficial transverse perineal) and sensory branches to the vestibular bulbs, vestibule, and lower part of the vagina. Although data are limited, branches of perineal nerve may provide innervation to the distal part or the striated urogenital sphincter muscles (compressor urethrae and urethrovaginalis), which are found in the deep perineal pouch, superior to the perineal membrane. The dorsal nerve of the clitoris may also contribute branches to these structures.

*Inferior anal (rectal) nerve* (see **FIG. 1.14**). The inferior anal nerve innervates the external anal sphincter and perianal skin. Thus, injury to this nerve may lead to fecal incontinence and pain syndromes. The path of the inferior rectal nerve differs from that of the other pudendal nerve branches in that this nerve does not enter the pudendal canal in ~50% of specimens examined in cadaver studies. This finding may have clinical implications in certain surgical

procedures where the ischioanal fossa is entered and during radiographic-guided injections used to manage pain.

## Autonomic Innervation to Erectile Structures

The erectile tissues of the perineum are innervated by the cavernous nerves of the clitoris. These are the distal extensions of the uterovaginal plexus, a component of the inferior hypogastric plexus. These fibers course within the paravaginal and paraurethral connective tissue and reach the perineum by passing under the pubic bones. Fibers join the dorsal nerve of the clitoris and provide innervation to the corpora cavernosa. In contrast to the dorsal nerve of the clitoris, the cavernous nerve fibers are of very small caliber and their presence can only be confirmed by microscopy. These nerves consist of sympathetic and parasympathetic components and are critical to sexual function. Injury to the inferior hypogastric plexus during radical hysterectomy or other extensive pelvic or perineal surgeries can lead to varying degrees of voiding, sexual, and defecatory dysfunction. Anti-incontinence procedures where sutures or trocars are passed through the paraurethral tissue may also disrupt these fibers within the retropubic space.

## Lymphatic Drainage

Injection studies and clinical observation have established the pattern of the vulvar lymphatic vessels and drainage into the superficial inguinal group of lymph nodes. This anatomy is important to the treatment of vulvar malignancies; an overview of this system is provided here.

Tissues external to the hymenal ring are supplied by an anastomotic series of vessels and lymphatics in the superficial tissues that coalesce to a few trunks lateral to the clitoris and proceed laterally to the superficial inguinal nodes (**FIG. 1.17**). The vessels draining the labia majora also run in an anterior direction, lateral to those of the labia minora and vestibule. These lymphatic

channels lie medial to the labiocrural fold, establishing it as the lateral border of surgical resection for vulvar malignancies.

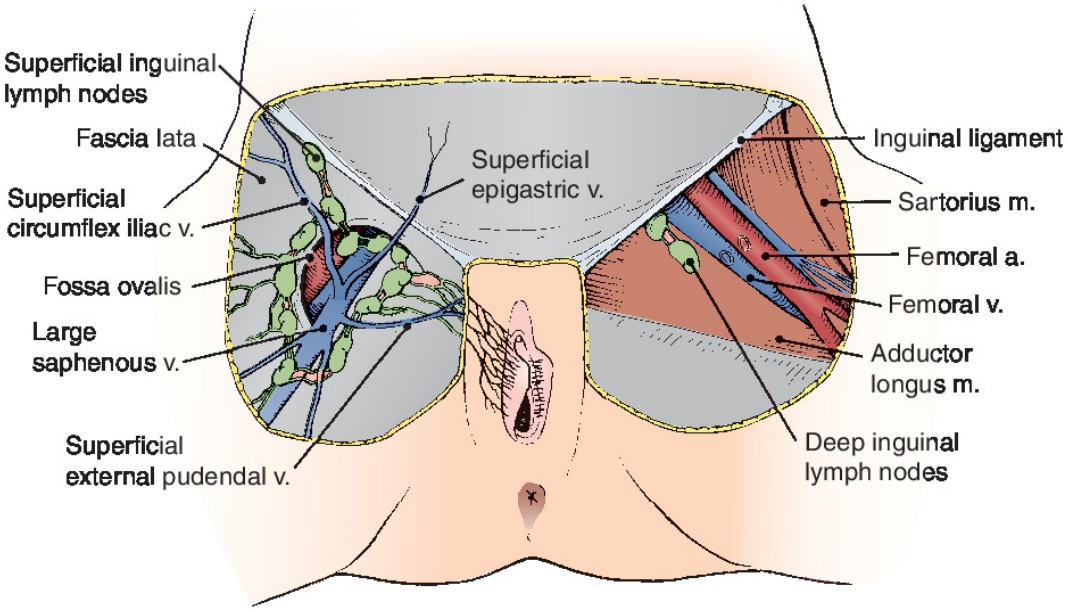


**FIGURE 1.17** Lymphatic drainage of the vulva and femoral triangle. Superficial inguinal nodes are shown in the right thigh, and deep inguinal nodes are shown in the left thigh. Fascia lata has been removed on the *left*.

Injection studies of the urethral lymphatics have shown that lymphatic drainage of this region terminates in either the right or left inguinal nodes. The clitoris has been said to have some direct drainage to deep pelvic lymph nodes, bypassing the usual superficial nodes, but the clinical significance of this appears to be minimal.

The inguinal lymph nodes are divided into two groups—the superficial and the deep nodes. There are 12-20 superficial nodes, and they lie in a T-shaped distribution parallel to and 1 cm below the inguinal ligament, with the stem extending down along the saphenous vein. The nodes are often divided into four quadrants, with the center of the division at the saphenous opening (fossa

ovalis). The vulvar drainage goes primarily to the medial nodes of the upper quadrant. These nodes lie deep in the adipose layer of the subcutaneous tissues, in the membranous layer, just superficial to the fascia lata.

The large saphenous vein joins the femoral vein through the saphenous opening. Within 2 cm of the inguinal ligament, several superficial blood vessels branch from the saphenous vein and femoral artery. They include the superficial epigastric vessels that supply the subcutaneous tissues of the lower abdomen, the superficial circumflex iliac vessels that course laterally to the region of the iliac crest, and the superficial external pudendal vessels that supply the mons, labia majora, and prepuce of clitoris.

Lymphatics from the superficial nodes enter the saphenous opening and drain into one to three deep inguinal nodes, which lie in the femoral canal of the femoral triangle. They pass through the saphenous opening in the fascia lata, which lies ~3 cm below the inguinal ligament, lateral to the pubic tubercle, along with the saphenous vein on its way to the femoral vein. The membranous layer of the subcutaneous tissues spans this opening as a trabeculate layer called the cribriform fascia, pierced by lymphatics. The deep nodes are found under this fascia in the femoral triangle.

# Medial Thigh Compartment

The medial thigh compartment is one of three anatomic divisions of the thigh. The muscles of the medial thigh primarily function to adduct the thigh at the hip joint. The most anterior and lateral adductor muscle is the pectineus, which originates on the pectineal line of the pubis and inserts onto the femur. This muscle contributes to the floor of the femoral triangle in the anterior thigh, and its primary function is hip flexion. As this muscle has a dual innervation as discussed below, it is considered a transitional muscle between the anterior thigh and medial thigh compartments. Medial to the pectineus muscle is the adductor longus muscle, which originates on the superior ramus of the pubis and inserts onto the femur. It forms the medial border of the femoral triangle. Its main action is to adduct and flex the thigh. The gracilis muscle forms the medial border of this

region and is the most superficial muscle in the medial thigh. It originates on the body of the pubis and the upper half of the inferior pubic ramus and inserts onto the proximal and medial surface of the tibia. This muscle crosses both the hip and knee joints, and its main function is adduction of the thigh at the hip and flexion of the leg at the knee. Between the adductor longus and gracilis lie the adductors magnus and brevis muscles. The adductor brevis lies underneath the adductor longus and between the anterior and posterior branches of the obturator nerve. It originates on the body of the pubis and the inferior pubic ramus. Its function is to adduct the thigh. The adductor magnus is the largest muscle in the medial compartment and lies posterior to the other muscles. It has an adductor part, which originates from the ischiopubic ramus and inserts along the posterior shaft of the femur, and a hamstring head, which originates from the ischial tuberosity and inserts on the medial epicondyle of the femur. The primary action of the adductor part is adduction, and the primary action of the hamstring part is hip extension. Beneath these three adductor muscles lies the obturator externus, which originates from the distal surface of the obturator membrane and adjacent bone and inserts onto the femur. The primary action of the obturator externus is the same as that of the obturator internus muscle, which is lateral rotation of the hip.

The muscles of the medial thigh compartment receive blood supply from the femoral and obturator arteries. Although significant variability exists, presented here is a frequent pattern of blood supply. The profunda femoris is a branch of the femoral artery that supplies the pectineus and adductors longus, brevis, and magnus. A smaller branch of this vessel, the medial circumflex femoral artery, perforates the adductor brevis, obturator externus, and gracilis muscles. The obturator artery passes through the obturator canal and then separates into anterior and posterior branches, which encircle the obturator membrane. Its branches supply the pectineus and obturator externus muscles. Deep veins of the thigh correspond with the major arteries described.

The major source of innervation to the medial thigh is from the obturator nerve. It enters the thigh through the obturator canal and promptly separates into anterior and posterior branches, which travel

on the anterior and posterior aspects of the adductor brevis muscle. The anterior branch supplies the adductors longus and brevis muscles. The posterior branch supplies the gracilis, adductors brevis and magnus, and obturator externus muscles. The hamstring head of the adductor magnus receives innervation from the tibial branch of the sciatic nerve. Notably, though the pectineus muscle is anatomically part of the medial thigh and may receive some innervation from the anterior branch of the obturator nerve, it receives primary innervation from the femoral nerve. The obturator nerve was described earlier under lumbar plexus branches. Symptoms of obturator nerve injury may include medial thigh or groin pain, weakness with thigh adduction, and sensory loss in the medial thigh of the affected side.

# THE PELVIC FLOOR

When humans assumed the upright posture, the opening in the bony pelvis came to lie at the bottom of the abdominopelvic cavity. This required the evolution of a supportive system to prevent the pelvic organs from being pushed downward through this opening. In the woman, this system must withstand these downward forces but allow for the passage of the large and cranially dominant human fetus. The supportive system that has evolved to meet these needs consists of a fibromuscular floor that forms a shelf spanning the pelvic outlet and that contains a cleft for the birth canal and excretory drainage. A series of visceral ligaments and fasciae tethers the organs and maintains their position over the closed portions of the pelvic diaphragm muscles (levators) and covering fasciae. The openings in the pelvic diaphragm and in the perineal membrane for parturition and elimination have required the development of ancillary fibrous elements that are concentrated over open areas in the muscular floor to support the viscera in these weak areas. This section discusses the structures of the perineal portion of the pelvic floor; the fibrous supportive system is described in the section on the pelvic viscera and cleavage planes and fascia.

# Perineal Membrane

The perineal membrane forms the inferior portion of the anterior pelvic floor below the levator muscles and covering fasciae. It is a triangular sheet of dense, fibromuscular tissue that spans the anterior half of the pelvic outlet, separating the superficial from the deep perineal pouch (see **FIG. 1.13**). It was previously called the urogenital diaphragm, and this change in name reflects the appreciation that it is not a two-layered structure with muscle in between, as was previously thought. It lies just caudal to the skeletal muscle of the striated urogenital sphincter (formerly the deep transverse perineal muscle). Because of the presence of the vagina, the perineal membrane cannot form a continuous sheet to close off the anterior pelvis in the woman, as it does in the man. It does provide support for the posterior vaginal wall by attaching the vagina and perineal body to the ischiopubic rami, thereby limiting their downward descent. This layer of the floor arises from the inner aspect of the inferior ischiopubic rami superior to the ischiocavernosus muscles and the crura of the clitoris. The medial attachments of the perineal membrane are to the urethra, walls of the vagina (approximately at the level of hymenal ring), and perineal body.

Just cephalad to the perineal membrane, in the deep pouch of anterior perineal triangle lie two arch-shaped striated muscles that begin posteriorly and pass anteriorly to arch over the urethra (**FIG. 1.18**). These are the compressor urethrae and the sphincter urethrovaginalis muscles. They are a part of the striated urogenital sphincter muscle in the woman and are continuous with the external urethral sphincter muscle. They act to compress the distal urethra. Posteriorly, intermingled within the membrane are skeletal muscle fibers of the transverse vaginal muscle and some smooth muscle fibers. Parts of the dorsal and deep nerve and vessels of the clitoris are also found within this membrane and were described previously. The primary function of the perineal membrane is related to its attachment to the vagina and perineal body. By attaching these structures to the bony pelvic outlet, the perineal membrane supports the perineal part of the pelvic floor against gravity and the effects of

increases in intra-abdominal pressure. The anterior part of pubococcygeus and puborectalis portions of the levator ani muscles lie just at the upper margin of the perineal membrane contacting its cranial surface. Contraction of these muscles elevates the medial margin of the perineal membrane (along with the vagina), while relaxation allows for its caudal movement. The amount of downward descent that is permitted by the connections of the perineal membrane to the midline structures can be assessed during an examination under anesthesia by placing a finger in the rectum, hooking it forward, and gently pulling the perineal body downward. If the perineal membrane has been torn during parturition, then an abnormal amount of descent is detectable, and the pelvic floor sags and the introitus gapes.

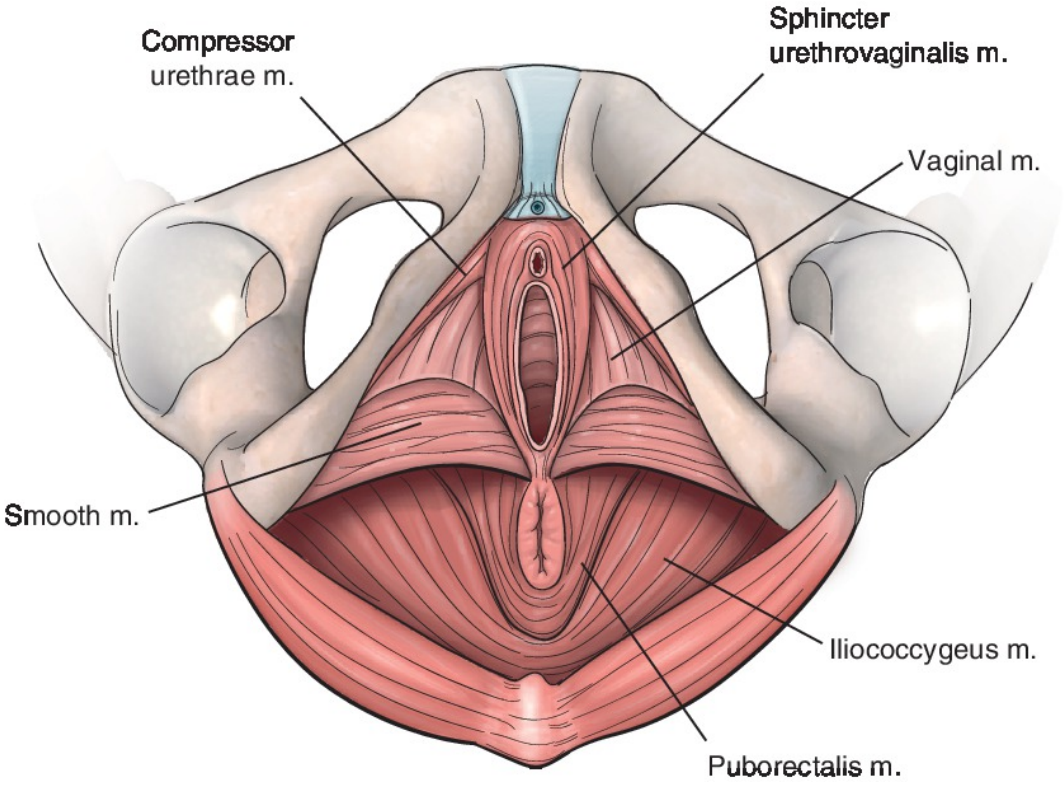


**FIGURE 1.18** Structures visible within deep perineal pouch/compartment after removal of

the superficial perineal muscles and perineal membrane.

## Perineal Body

Within the area bounded by the lower vagina, perineal skin, and anus is a mass of fibromuscular tissue called the perineal body (see **FIG. 1.14**). The term *central point (tendon) of the perineum* has been applied to this structure and is descriptive, suggesting its role as a central point into which many muscles insert.

The perineal body is attached to the inferior pubic rami and ischial tuberosities through the perineal membrane and superficial transverse perineal muscles. Anterolaterally, it receives the insertion of the bulbospongiosus muscles. On its lateral margins, the upper portions of the perineal body are connected with some fibers of the pelvic diaphragm, the puboperinealis portion of the pubococcygeus muscle. Posteriorly, the perineal body is indirectly attached to the coccyx by the external anal sphincter. These connections anchor the perineal body and its surrounding structures to the bony pelvis and help to keep it in place.

## Posterior Triangle: Ischioanal Fossa

In the posterior triangle of the pelvis, the ischioanal fossa lies between the obturator muscle and medial layer of fascia at the perineal walls and the levator ani muscles and its inferior layer of fascia (see **FIG. 1.14**). It has an anterior recess that lies above the perineal membrane. It is bounded superomedially by the levator ani muscles and laterally by the obturator internus muscle. The main portion of the fossa is lateral to the levator ani and external anal sphincter, and it has a posterior portion that extends above the gluteus maximus. Traversing this fossa is the pudendal neurovascular trunk. The pudendal canal with neurovascular bundle lies on its lateral wall.

# Anal Sphincters

The external anal sphincter lies in the posterior triangle of the perineum (**FIG. 1.19**). It is a single mass of muscle that has traditionally been divided into a subcutaneous, superficial, and deep portion. The subcutaneous part lies attached to the perianal skin and forms an encircling ring around the anal canal. It is responsible for the characteristic radially oriented folds in the perianal skin. The superficial part attaches to the coccyx posteriorly, contributing to the anococcygeal body, and sends a few fibers into the perineal body anteriorly. The superficial part of the external anal sphincter forms the bulk of the anal sphincter when seen separated in third-degree midline obstetric tears. The fibers of the deep part generally encircle the rectum and blend indistinguishably with the puborectalis, which forms a loop under the dorsal surface of the anorectum and which is attached anteriorly to the pubic bone (see **FIG. 1.19**).

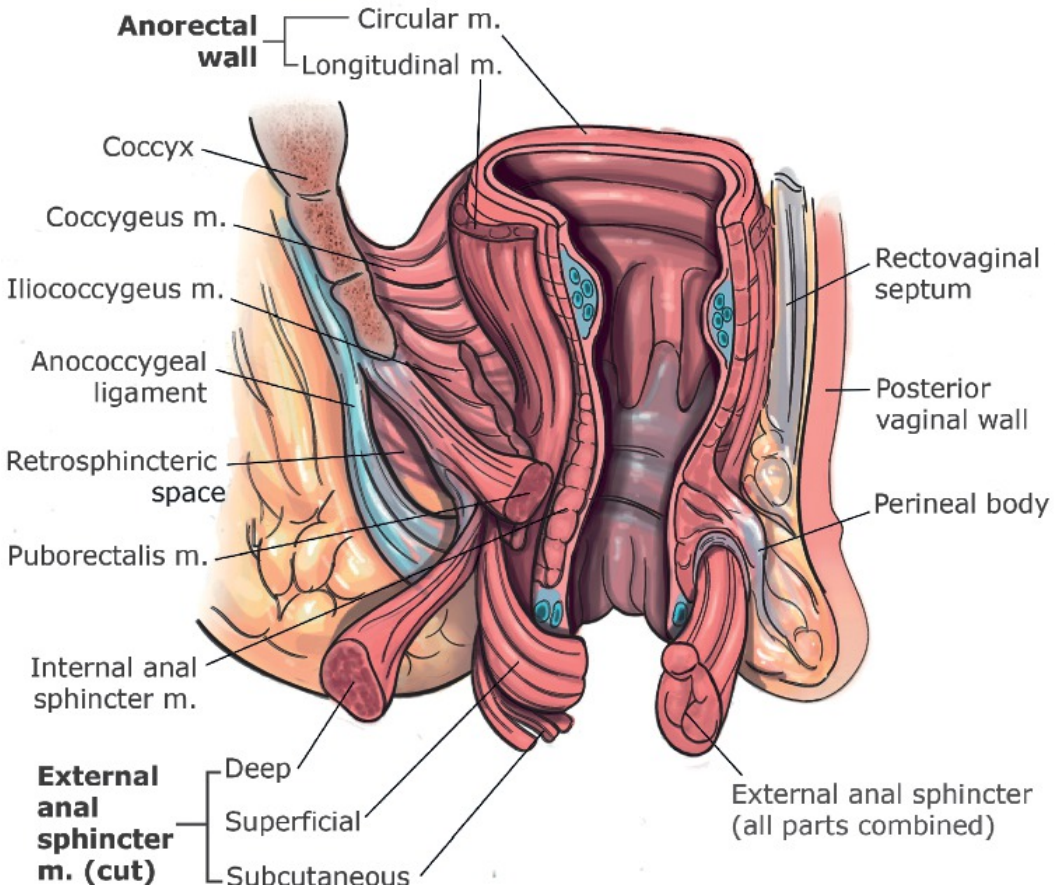

**FIGURE 1.19** Schematic view of anorectal region in midsagittal plane. The external anal sphincter muscle is cut laterally and reflected to show its subcutaneous, superficial and deep parts. Note relationship of anterior muscle bundle to the perineal body. Note some external anal sphincter muscle attachment to the coccyx posteriorly. Puborectalis was cut from its anterior attachment to pubic bone and reflected posteriorly. Note proximity of deep part of external anal sphincter to the puborectalis muscle. Note internal anal sphincter's origin from the circular muscle layer of anorectal wall and its position relative to the external anal sphincter.

The internal anal sphincter is a thickening in the circular smooth muscle of the anal wall. It lies just inside the external anal sphincter and is separated from it by a visible intersphincteric groove. It extends downward inside the external anal sphincter to within a few millimeters of the external sphincter's caudal extent. The internal sphincter can be identified just outside the anal submucosa in repair of a chronic fourth-degree laceration as a rubbery white layer that is often erroneously been referred to as fascia during obstetrical repair of fourth-degree laceration. The longitudinal smooth muscle layer of the bowel, along with some fibers of the levator ani, separates the external and internal sphincters as they descend in the intersphincteric groove.

# Levator Ani Muscles

The typical depiction of the levator ani muscles in anatomy textbooks is unfortunately distorted by the extreme abdominal pressures generated during embalming that forces them downward. Many of these illustrations therefore fail to give a true picture of the horizontal nature of this strong supportive shelf of muscle. Examination of the normal standing patient is the best way to appreciate the nature of this closure mechanism, because the lithotomy position causes some relaxation of the musculature. During routine pelvic examination of the nullipara, the effectiveness of this closure can be appreciated, because it is often difficult to insert a speculum if the muscles are contracted.

The bony pelvis is spanned by the levator muscles of the pelvic diaphragm. This diaphragm consists of two components: (1) a thin horizontal shelflike layer formed by the iliococcygeus muscle and (2) a thicker “U”-shaped sling of muscles that surround the levator hiatus that include the pubococcygeus and puborectalis muscles (**FIG. 1.20**). The open area within the U (through which the urethra, vagina, and rectum pass) is called the levator hiatus, and the portion of the hiatus anterior to the perineal body is called the urogenital hiatus.

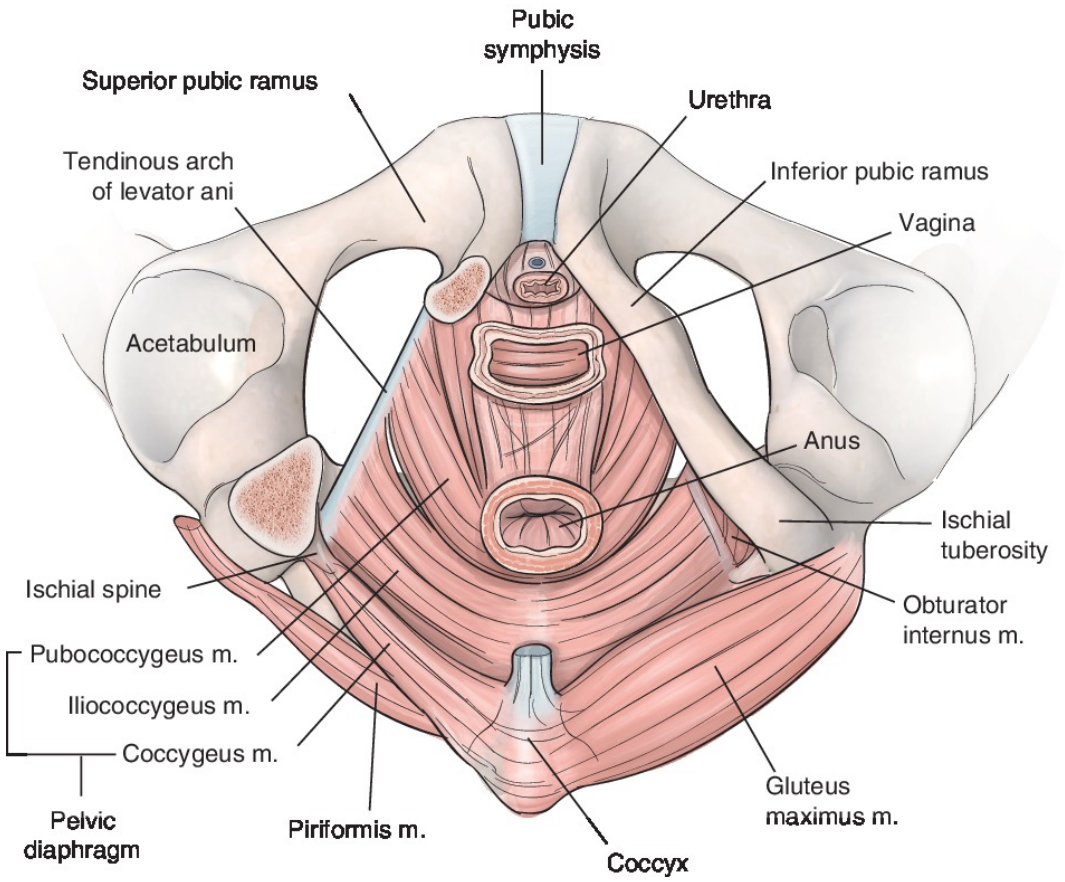


**FIGURE 1.20** Anatomy of the pelvic floor, perineal view.

The pubococcygeus muscle arises from a thin aponeurotic attachment to the inner surface of the pubic bone and inserts to the distal lateral vagina, perineal body, and anus. Some fibers also attach to the superior surface of the coccyx, hence the name pubococcygeus. Because the majority of the attachments, however, are to the vagina and anus, the term pubovisceral muscle is replacing this older term.

The puborectalis muscle is distinct from the pubococcygeus muscle and lies lateral to it. Its fibers originate from the lower pubis and some from the top of the perineal membrane. The muscle fibers pass beside the rectum forming a sling behind the anorectal junction.

The iliococcygeus muscle arises from a fibrous band overlying the obturator internus called the tendinous arch of levator ani. From

these broad origins, the fibers of the iliococcygeus pass behind the rectum and insert into the midline anococcygeal body, which includes the iliococcygeal raphe, and the coccyx. The ischiococcygeus (coccygeus) muscle arises from the ischial spine and sacrospinous ligament to insert into the borders of the coccyx and the lowest segment of the sacrum.

These muscles are covered on their superior and inferior surfaces by fasciae. When the levator ani and ischiococcygeus muscles and their fasciae are considered together, they are called the pelvic diaphragm, not to be confused with the perineal membrane (formerly called the urogenital diaphragm).

The normal tone of the muscles of the pelvic diaphragm keep the base of the U in the levator hiatus close to the backs of the pubic bones, keeping the vagina and rectum closed. The region of the levator ani between the anus and coccyx formed by the anococcygeal body and iliococcygeal raphe is clinically called the levator plate. It forms a supportive shelf on which the rectum, upper vagina, and uterus can rest. The relatively horizontal position of this shelf is determined by the anterior traction on the fibromuscular levator plate by the pubococcygeus and puborectalis muscles and is important to vaginal and uterine support.

The levator ani muscles receive their innervation from an anterior branch of the anterior ramus of the third, fourth, and fifth sacral nerves called, appropriately, the nerve to the levator ani, which perforates the muscle from its pelvic surface. Some parts of the puborectalis muscle may also receive a small contribution from the inferior anal (rectal) branch of the pudendal nerve.

# PELVIC VISCERA

This section on the pelvic viscera discusses the structure of the individual pelvic organs and considers specific aspects of their interrelations (**FIG. 1.21**). Those aspects of blood supply, innervation, and lymphatic drainage that are unique to the specific pelvic viscera are covered here. However, the section on the retroperitoneum, where the overall description of these systems is

given, provides the general consideration of the pelvic vasculature, innervation, and lymphatic drainage.

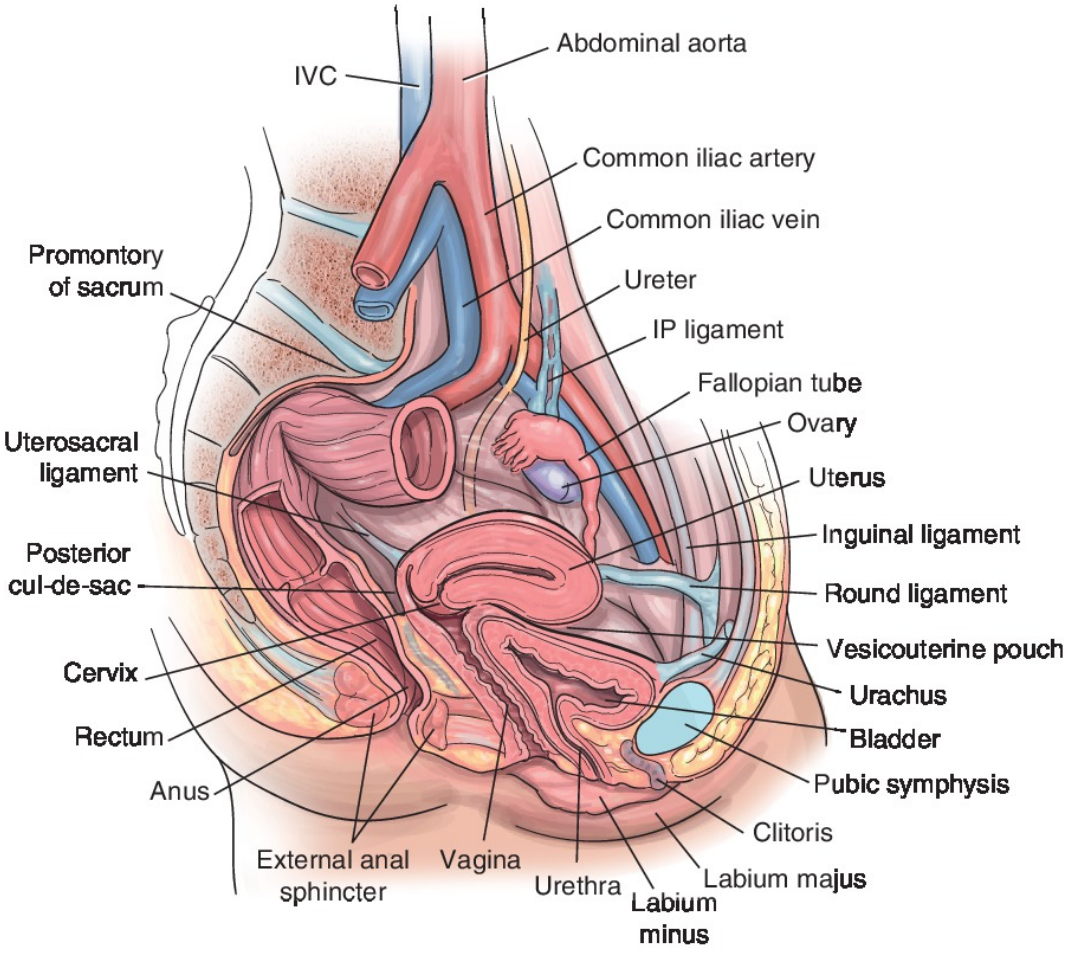


**FIGURE 1.21** The pelvic viscera.

# Genital Structures

## *Vagina*

The vagina is a pliable hollow viscus with a shape that is determined by the structures surrounding it and by its attachments to the pelvic wall. These attachments are to the lateral margins of the vagina, so that its lumen is a transverse slit, with the anterior and posterior walls in contact with one another. The lower portion of the vagina is

constricted as it passes through the urogenital hiatus. The upper part is much more capacious. The vagina is bent at an angle of 120° by the anterior traction of the levator ani muscles at the junction of the lower one-third and upper two-thirds of the vagina (**FIG. 1.22**). The cervix typically lies within the anterior vaginal wall, making the anterior vaginal wall shorter than the posterior wall by 2-3 cm. The anterior wall is about 7-9 cm in length, although there is great variability in this dimension.

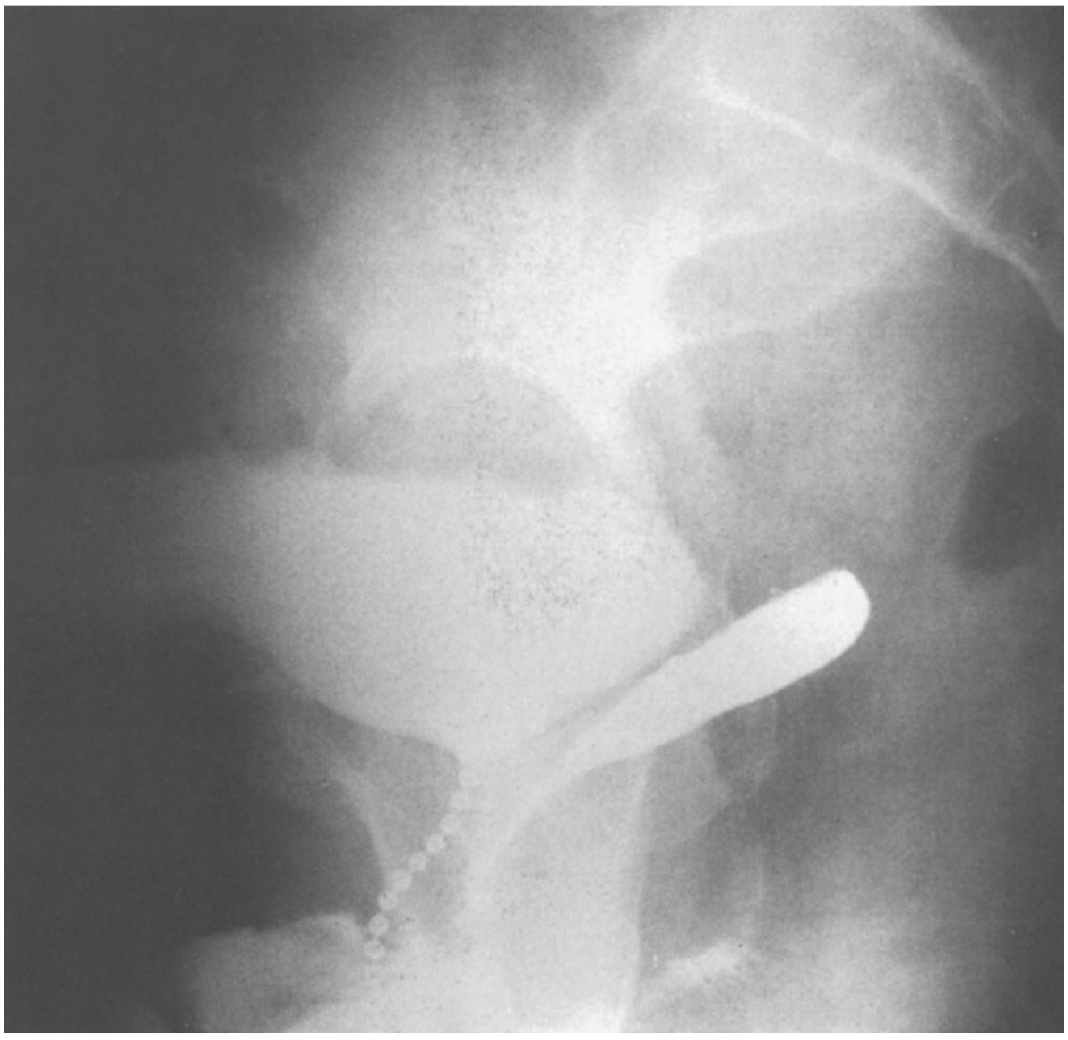

**FIGURE 1.22** Bead-chain cystourethrogram (with barium in the vagina) showing the

normal vaginal axis in a patient in the standing position.

When the lumen of the vagina is inspected through the introitus, many landmarks can be seen. The anterior and posterior walls have a midline ridge, called the anterior and posterior columns, respectively. These are caused by the impression of the urethra and bladder and the rectum on the vaginal lumen. The caudal portion of the anterior column is distinct and is called the urethral carina of the vagina. The recesses in front of, behind, and lateral to the cervix are called the anterior, posterior, and lateral fornices of the vagina, respectively. The creases along the side of the vagina, where the anterior and posterior walls meet, are called the lateral vaginal sulci.

The vagina's relations to other parts of the body can be understood by dividing it into thirds. In the lower third, the vagina is fused anteriorly with the urethra, posteriorly with the perineal body, and laterally to each levator ani by the "fibers of Luschka." The portion of the pubococcygeus muscle that attaches to the vagina is called the pubovaginalis. In the middle third are the vesical neck and trigone anteriorly, the rectum posteriorly, and the levators laterally. In the upper third, the anterior vagina is adjacent to the bladder, posterior to the cul-de-sac, and lateral to the cardinal ligaments.

The vaginal wall contains the same layers as all hollow viscera (ie, mucosa, submucosa, muscularis, and adventitia). The adventitial layer represents the visceral fascia surrounding a pelvic organ as discussed below. Except for the area covered by the cul-de-sac, the vagina has no serosal covering. The mucosa consists of the epithelium and lamina propria layers. It is of the nonkeratinized stratified squamous type and lies on a dense, dermislike submucosa.

The vaginal muscularis is fused with the submucosa, and the pattern of the muscularis is a bihelical arrangement. Outside the muscularis, the adventitial layer or visceral pelvic fascia has varying degrees of development in different areas of the vagina. Visceral pelvic fascia is a component of the endopelvic fascia and has been given a separate name because of its unusual development. When it is dissected in the operating room, the muscularis is usually

adherent to it, and this combination of specialized adventitia and muscularis is the surgeon's "fascia," which might better be called the fibromuscular layer of the vagina, as Nichols and Randall suggested in *Vaginal Surgery*.

# *Uterus*

The uterus is a fibromuscular organ with shape, weight, and dimensions that vary considerably, depending on both estrogenic stimulation and previous parturition. It has two portions: an upper muscular body and a lower fibrous cervix. In a woman of reproductive age, the body is considerably larger than the cervix, but before menarche, and after the menopause, their sizes are similar. Within the body, there is a triangularly shaped endometrial cavity surrounded by a thick muscular wall. That portion of the uterus that extends above the top of the endometrial cavity (ie, above the insertions of the uterine tubes) is called the fundus.

The muscle fibers that make up most of the uterine body are not arranged in a simple layered manner, as is true in the gastrointestinal tract, but are arranged in a more complex pattern. This pattern reflects the origin of the uterus from paired paramesonephric primordia, with the fibers from each half crisscrossing diagonally with those of the opposite side.

The uterus is lined by a unique mucosa, the endometrium. It has both a columnar epithelium that forms glands and a specialized stroma. The superficial portion of this layer undergoes cyclic change with the menstrual cycle. Spasm of hormonally sensitive spiral arterioles that lie within the endometrium causes shedding of this layer after each cycle, but a deeper basal layer of the endometrium remains to regenerate a new lining. Separate arteries supply the basal endometrium, explaining its preservation at the time of menses.

The cervix is divided into two portions: the vaginal part, which is that part protruding into the vagina, and the supravaginal part, which lies above the vagina and below the body.

The cervical wall, especially its distal segment, is primarily composed of dense, fibrous connective tissue with only a small

amount (~10%) of smooth muscle. This smooth muscle is located peripherally within the cervix, connecting the myometrium with the muscle of the vaginal wall. This smooth muscle and accompanying fibrous tissue are easily dissected off the underlying, denser fibrous cervix core and form the layer reflected during intrafascial hysterectomy. It is circularly arranged around the fibrous cervix and is the tissue into which the cardinal and uterosacral ligaments attach.

The vaginal part is covered by nonkeratinizing squamous epithelium. Its canal is lined by a columnar mucous-secreting epithelium that is thrown into a series of V-shaped folds that appear like the leaves of a palm and are therefore called palmate folds. These form compound clefts in the cervical canal, not tubular racemose glands, as formerly thought.

The upper border of the cervical canal is the internal os, above which the narrow cervical canal widens out into the endometrial cavity. The lower border of the canal is the external cervical os. The transition from the squamous epithelium of the vaginal part to the columnar epithelium of the cervical canal by the process of squamous metaplasia occurs near the external os. The resultant transformation zone is located variably in relation to the external os, changing with hormonal variations that occur during a woman's life. It is in this active area of cellular transition that the cervix is most susceptible to malignant transformation.

There is little adventitia in the uterus, with the peritoneal serosa being directly attached to most of the corpus. The anterior portion of the uterine cervix is covered by the bladder; therefore, it has no serosa. Similarly, as discussed in the following section, the broad ligament envelops the lateral aspects of the cervix and body of the uterus; therefore, it has no serosal covering there. The posterior cervix does have a serosal covering as the cul-de-sac peritoneum reflects onto the posterior vaginal wall several centimeters from the cervicovaginal junction.

## *Adnexal Structures and Broad Ligament*

The uterine (fallopian) tubes are paired tubular structures 7-12 cm in length (**FIG. 1.23**). Each has four recognizable portions. At the

uterus, the tube passes through the uterine wall (intramural part), also called the interstitial portion. On emerging from the body, a narrow isthmic portion begins with a narrow lumen and thick muscular wall. Proceeding toward the abdominal end, next is the ampulla, which has an expanding lumen and more convoluted mucosa. The fimbriated end of the tube has many frondlike projections to provide a wide surface for ovum pickup. The distal end of the fallopian tube is attached to the ovary by the ovarian fimbria or fimbria ovarica, which is a smooth muscle band responsible for bringing the fimbria and ovary close to one another at the time of ovulation. The outer layer of the tube's muscularis is composed of longitudinal fibers; the inner layer has a circular orientation.

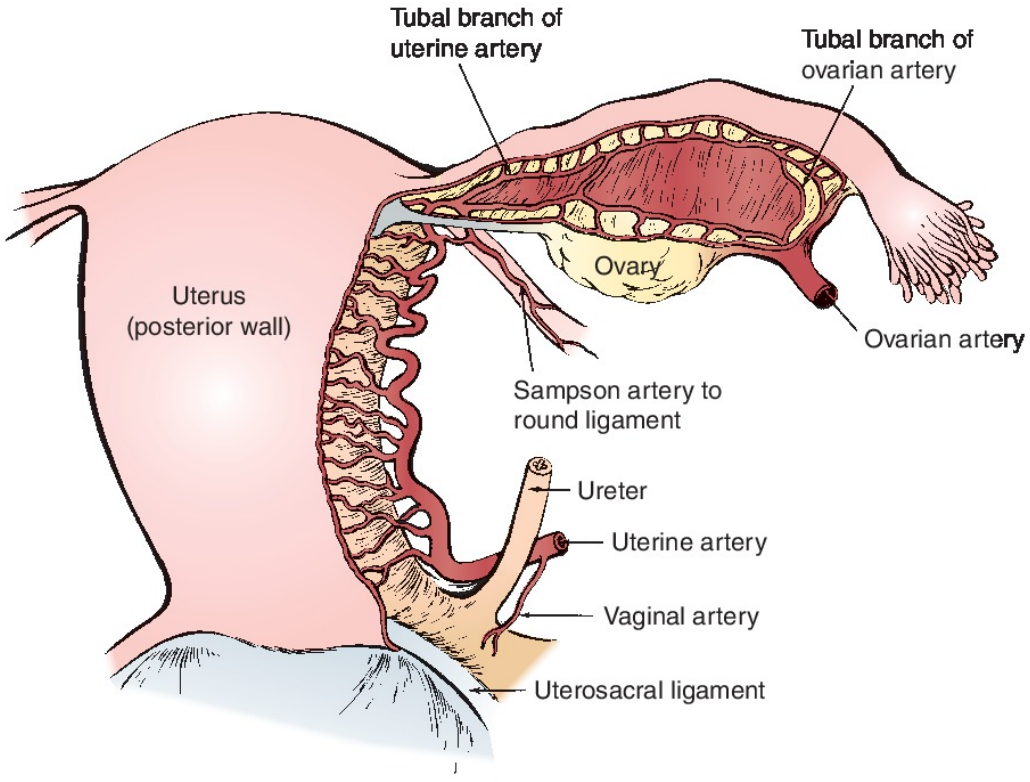


**FIGURE 1.23** Posterior view of uterine adnexa and collateral circulation of uterine and ovarian arteries. The uterine artery crosses over the ureter at the base of the

broad ligament and gives off cervical and vaginal branches before ascending adjacent to the wall of the uterus and anastomosing with the medial end of the ovarian artery. Note the small branch of the uterine or ovarian artery that supplies the round ligament (Sampson artery).

The lateral pole of the ovary is attached to the pelvic wall by the suspensory ligament of ovary (infundibulopelvic ligament), composed of the ovarian artery, vein, lymphatics, and nerve plexus. Medially, the ovary is connected to the uterus through the ligament of the ovary (utero-ovarian ligament). During reproductive life, the ovary measures about 2.5-5 cm long, 1.5-3 cm thick, and 0.7-1.5 cm wide, varying with its state of activity or suppression, as with oral contraceptive medications. Its surface is mostly free but has an attachment to the broad ligament through the mesovarium, as discussed below.

The ovary has a cuboidal to columnar covering and consists of a cortex and medulla. The medullary portion is primarily fibromuscular, with many blood vessels and much connective tissue. The cortex is composed of a more specialized stroma, punctuated with follicles, corpora lutea, and corpora albicantia.

The round ligaments of uterus are extensions of the uterine musculature and represent the homolog of the gubernaculum testis. They begin as broad bands that arise on each lateral aspect of the anterior corpus. They assume a more cylindrical shape before they enter the retroperitoneal tissue, where they pass lateral to the deep inferior epigastric vessels and enter each deep (internal) inguinal ring. After traversing the inguinal canal, they exit the superficial inguinal ring and enter the subcutaneous tissue of the labia majora. They have little to do with uterine support.

The ovaries and tubes constitute the uterine adnexa. They are covered by a specialized series of peritoneal folds called the broad

ligament. During embryonic development, the paired müllerian ducts and ovaries arise from the lateral abdominopelvic walls. As they migrate toward the midline, a mesentery of peritoneum is pulled out from the pelvic wall from the cervix on up. This leaves the midline uterus connected on either side to the pelvic wall by a double layer of peritoneum, called the broad ligament; these ligaments are described under the section on supportive tissues and cleavage planes.

At the superior margin of these two folds, called the broad ligament, lie the uterine tubes, round ligaments, and ovaries (**FIG. 1.24**). The cardinal and uterosacral ligaments are at the lower margin of the broad ligament. These structures are visceral ligaments; therefore, they are composed of varying amounts of smooth muscle, vessels, connective tissue, nerves, and other structures. They are not the pure ligaments associated with joints in the skeleton.

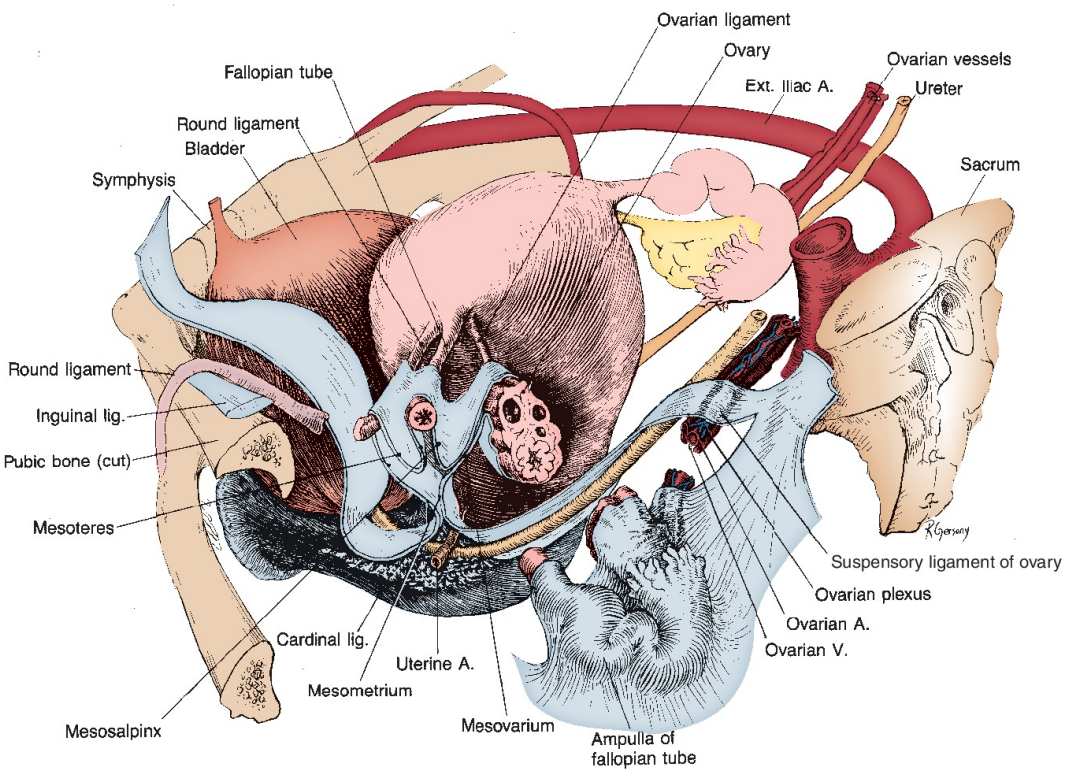


**FIGURE 1.24** Broad ligament composition.

The ovary, tube, and round ligament each have their own separate mesentery, called the mesovarium, mesosalpinx, and mesoteres, respectively. These are arranged in a consistent pattern, with the round ligament placed ventrally, where it exits the pelvis through the inguinal ligament, and the ovary placed dorsally. The tube is in the middle and is the most cephalic of the three structures. At the lateral end of the uterine tube and ovary, the broad ligament ends where the infundibulopelvic ligament blends with the pelvic wall. The cardinal ligaments lie at the base of the broad ligament and are described under the section on supportive tissues and cleavage planes.

## *Blood Supply and Lymphatics of the Genital Tract*

The blood supply to the genital organs comes from the ovarian arteries, branches of the abdominal aorta, and uterine and vaginal branches of the internal iliac arteries. A continuous arterial arcade connects these vessels on the lateral border of the adnexa, uterus, and vagina (see **FIG. 1.23**).

The blood supply of the adnexa comes from the ovarian arteries, which arise from the anterior surface of the aorta just below the level of the renal arteries. The accompanying plexus of veins drains into the vena cava on the right and the renal vein on the left. The arteries and veins follow a long, retroperitoneal course before reaching the cephalic end of the ovary. Because the ovarian artery runs along the hilum of the ovary, it not only supplies the gonad but also sends many small vessels through the mesosalpinx to supply the uterine tube, including a prominent fimbrial branch at the lateral end of the tube.

The uterine artery originates from the internal iliac artery. It sometimes shares a common origin with either the internal pudendal or vaginal artery. It joins the uterus near the junction of the body and cervix, but this position varies considerably, both between individuals and with the amount of upward or downward traction placed on the uterus. Accompanying each uterine artery are several large uterine veins that drain the body and cervix.

On arriving at the lateral border of the uterus (after passing over the ureter and giving off a small branch to this structure), the uterine artery flows into the artery that runs along the side of the uterus. Through this connection, it sends blood both upward toward the body and downward to the cervix. Because this descending branch of the uterine artery continues along the lateral aspect of the cervix, it eventually crosses over the cervicovaginal junction and lies on the side of the vagina.

The vagina receives its blood supply from a downward extension of the uterine artery along the lateral sulci of the vagina, called the vaginal branch of uterine artery or azygous artery of the vagina, and from a vaginal branch of the internal iliac artery. These form an anastomotic arcade along the lateral aspect of the vagina at the 3 o'clock and 9 o'clock positions. Branches from these vessels also merge along the anterior and posterior vaginal walls. The distal vagina also receives blood supply from the internal pudendal vessels, and the posterior wall receives a contribution from the middle and inferior rectal arteries.

Lymphatic drainage of the upper two-thirds of the vagina and uterus is primarily to the obturator and internal and external iliac nodes, and the distal-most vagina drains with the vulvar lymphatics to the inguinal nodes. In addition, some lymphatic channels from the uterine corpus extend along the round ligament to the superficial inguinal nodes, and some nodes extend posteriorly along the uterosacral ligaments to the lateral sacral nodes. These routes of drainage are discussed more fully in the discussion of the retroperitoneal space.

The lymphatic drainage of the ovary follows the ovarian vessels to the region of the lower abdominal aorta, where they drain into the lumbar chain of nodes (para-aortic nodes).

The uterus receives its nerve supply from the uterovaginal plexus (Frankenhäuser ganglion) that lies in the connective tissue of the cardinal ligament. Details of the organization of the pelvic innervation are contained in the section on retroperitoneal structures.

# Lower Urinary Tract

## *Ureter*

The ureter is a tubular viscus about 25-30 cm long, divided into abdominal and pelvic portions of equal length. Its small lumen is surrounded by an inner longitudinal and outer circular muscle layer. In the abdomen, it lies in the extraperitoneal connective tissue on the posterior abdominal wall, crossed anteriorly by the left and right colic vessels and the ovarian vessels. Its course and blood supply are described in the section on the retroperitoneum.

## *Bladder*

The bladder can be divided into two portions: the body (dome) and fundus (base) (**FIG. 1.25**). The musculature of the spherical bladder does not lie in simple layers, as do the muscular walls of tubular viscera, such as the gut and ureter. It is best described as a meshwork of intertwining muscle bundles. The musculature of the dome is relatively thin when the bladder is distended. The base of the bladder, which is thicker and varies less with distension, consists of the urinary trigone and a thickening of the detrusor, called the detrusor loop. This is a U-shaped band of musculature, open posteriorly, that forms the bladder base anterior to the intramural portion of the ureter. The trigone is made of smooth muscle that arises from the ureters that occupy two of its three corners. The detrusor loop continues as the muscle of the vesical neck and urethra. The vesical neck is the region of the bladder where the urethral lumen traverses the bladder base. There it rests on the mid vagina. The shape of the bladder depends on its state of filling. When empty, it is a somewhat flattened disk, slightly concave upward. As it fills, the dome rises off the base, eventually assuming a more spherical shape.

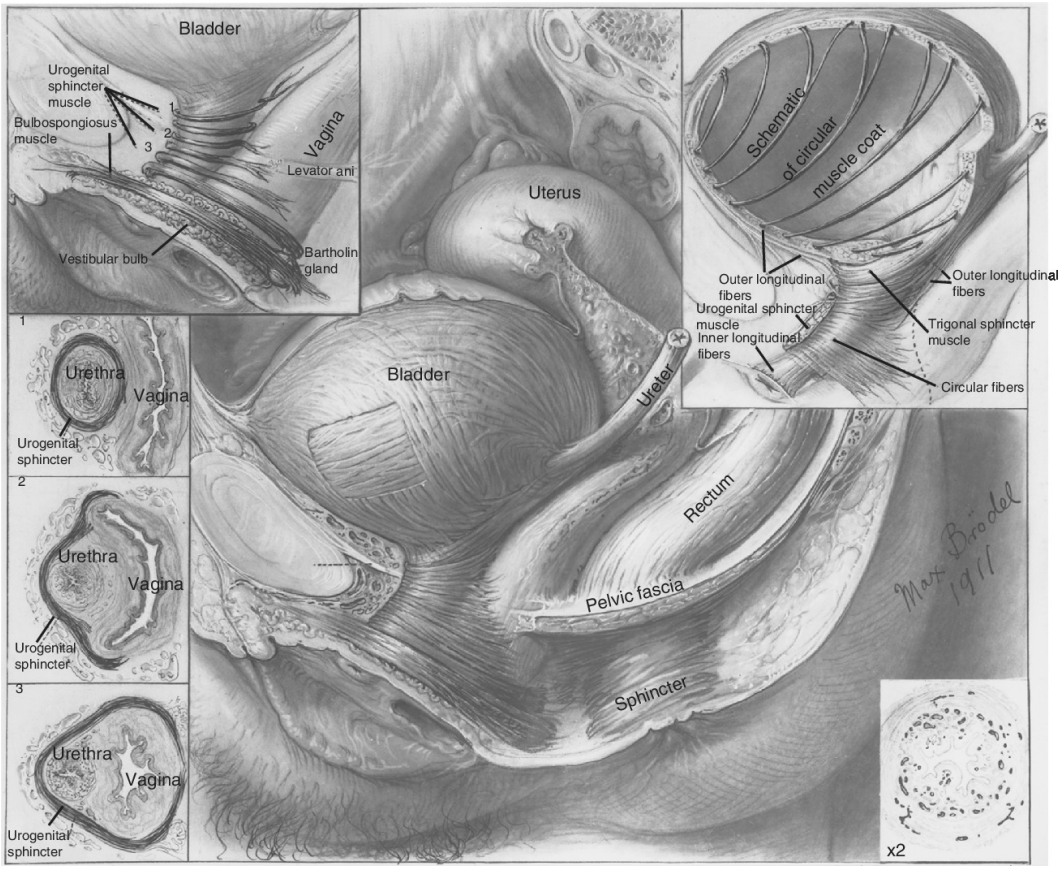


**FIGURE 1.25** Lateral view of the pelvic organs showing detailed anatomy of the urethra and bladder. *Insets* demonstrate composition of the smooth muscle fibers of the bladder and bladder neck (*top right*) and the striated urogenital sphincter complex (*left side insets*). The compressor urethra is not seen. (The original illustration is in the Max Brödel Archives in the Department of Art as Applied to Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA. Used with permission.)

The distinction between the base and dome has functional importance, because these two sections have differing innervations. The bladder base has α-adrenergic receptors that contract when stimulated and thereby favor continence. The dome is responsive to β or cholinergic stimulation, with contraction that causes bladder emptying.

Anteriorly, the bladder lies against the pubic bones and lower abdominal wall. The apex of the bladder is that part of the dome located superiorly and is connected to the umbilicus by the median umbilical ligament (remnant of urachus). The bladder lies against the pubic bones laterally and inferiorly and abuts the obturator internus and levator ani. Posteriorly, it rests against the vagina and cervix. These relations are discussed further in consideration of the pelvic planes and spaces.

The blood supply of the bladder comes from the superior vesical artery, which comes off the patent part of the umbilical artery and inferior vesical artery, which is either an independent branch of the internal pudendal artery or arises from the vaginal artery.

The nerve supply to the bladder is derived from the vesical plexus, a component of the inferior hypogastric plexus.

## *Urethra*

The urethral lumen begins at the internal urethral orifice (meatus) and has a series of regional differences in its structure. It passes through the bladder base in an intramural portion for a little less than a centimeter. This region of the bladder, where the urethral lumen traverses the bladder base, is called the vesical neck.

In its distal two-thirds, the urethra is fused with the vagina (see **FIG. 1.25**), with which it shares a common embryologic derivation from the urogenital sinus. From the vesical neck to the perineal membrane, which starts at the junction of the middle and distal thirds of the urethra, the urethra has several layers. An outer, circularly oriented skeletal muscle layer (urogenital sphincter) mingles with some circularly oriented smooth muscle fibers. Inside this layer is a longitudinal layer of smooth muscle that surrounds a remarkably vascular submucosa and nonkeratinized squamous epithelium that

responds to estrogenic stimulation. The proximal urethral lumen is lined by a urothelial layer.

Within the thick, vascular lamina propria or submucosal layer is a group of tubular glands that lie on the vaginal surface of the urethra. These paraurethral glands empty into the lumen at several points on the posterolateral surface of the urethra, but they are most prominent over the distal two-thirds. Skene glands are the largest and most distal of these glands and drain outside the urethral lumen, posterolateral to the external urethral orifice. Chronic infection of these glands can lead to urethral diverticula, and obstruction of their terminal duct can result in gland cyst formation. Skene gland cysts typically result in deviation of the urethral opening to the contralateral side. Their location on the dorsal surface of the urethra reflects the distribution of the structures from which they arise. Paraurethral glands, as the lower vagina and urethra, are derived from the urogenital sinus, and, thus, gland cysts are typically lined with stratified squamous epithelium.

At the level just above the perineal membrane, the distal portion of the urogenital sphincter begins. Here, the skeletal muscle of the urethra leaves the urethral wall to form the sphincter urethrovaginalis (see **FIG. 1.18**) and compressor urethrae (formerly called the deep transverse perineal muscle). Distal to this portion, the urethral wall is fibrous and forms a nozzle for aiming the urinary stream. The mechanical support of the vesical neck and urethra, which are so important to urinary continence, is discussed in the section of this chapter devoted to the supportive tissues of the urogenital system.

The urethra receives its blood supply both from an inferior extension of the vesical vessels and from the pudendal vessels.

The striated muscles of the urethra are innervated by the somatic nervous system via the pudendal nerve or direct branches of the sacral plexus, and the smooth muscle is supplied by the inferior hypogastric plexus.

# Sigmoid Colon and Rectum

The sigmoid colon begins its S-shaped curve at the pelvic brim. It has the characteristic structure of the colon, with three taeniae coli

lying over a circular smooth muscle layer. Unlike much of the colon, which is retroperitoneal, the sigmoid has a definite mesentery in its midportion. The length of the mesentery and the pattern of the sigmoid's curvature vary considerably. It receives its blood supply from the lowermost portion of the inferior mesenteric artery: the branches called the sigmoid arteries.

As it enters the pelvis, the colon straightens its course and becomes the rectum. This portion extends from the pelvic brim until it loses its final anterior peritoneal investment below the cul-de-sac. It has two bands of smooth muscle (anterior and posterior). Its lumen has three transverse rectal folds that contain the mucosa, submucosa, and circular layers of the bowel wall. The most prominent fold, the middle one, lies anteriorly on the right about 8 cm above the anus, and it must be negotiated during high rectal examination or sigmoidoscopy.

As the rectum passes posterior to the vagina, it expands into the rectal ampulla. This portion of the bowel begins under the cul-de-sac peritoneum and fills the posterior pelvis from the side. At the distal end of the rectum, the anorectal junction is bent at an angle of 90° where it is pulled ventrally by the puborectalis fibers' attachment to the pubis and posteriorly by the external anal sphincter's dorsal attachment to the coccyx. Unlike other portions of the colon, the rectum does not have taeniae coli.

Below this level, the gut is called the anus. It has many distinguishing features. There is a thickening of the circular involuntary muscle called the internal anal sphincter. The canal has a series of anal valves to assist in closure, and at their lower border, pectinate (dentate) line, the mucosa of the colon gives way to a transitional layer of non-hair–bearing squamous epithelium before becoming the hair-bearing perineal skin at the anocutaneous line.

The relations of the rectum and anus can be inferred from their course. They lie against the sacrum and levator plate posteriorly and against the vagina anteriorly. Inferiorly, each half of the levator ani abuts its lateral wall and sends fibers to mingle with the longitudinal involuntary fibers between the internal and external anal sphincters. Its distal terminus is surrounded by the external anal sphincter.

The anorectum receives its blood supply from a number of sources (**FIG. 1.26**). From above, the superior rectal branch of the inferior mesenteric artery lies within the layers of the sigmoid mesocolon. As it reaches the beginning of the rectum, it divides into two branches and ends in the wall of the gut. A direct branch from the internal iliac artery, the middle rectal, arises from the pelvic wall on either side and contributes to the blood supply of the rectum and ampulla above the pelvic floor. The anus and external sphincter receive their blood supply from the inferior rectal branch of the internal pudendal artery, which reaches the terminus of the gastrointestinal tract through the ischioanal fossa.

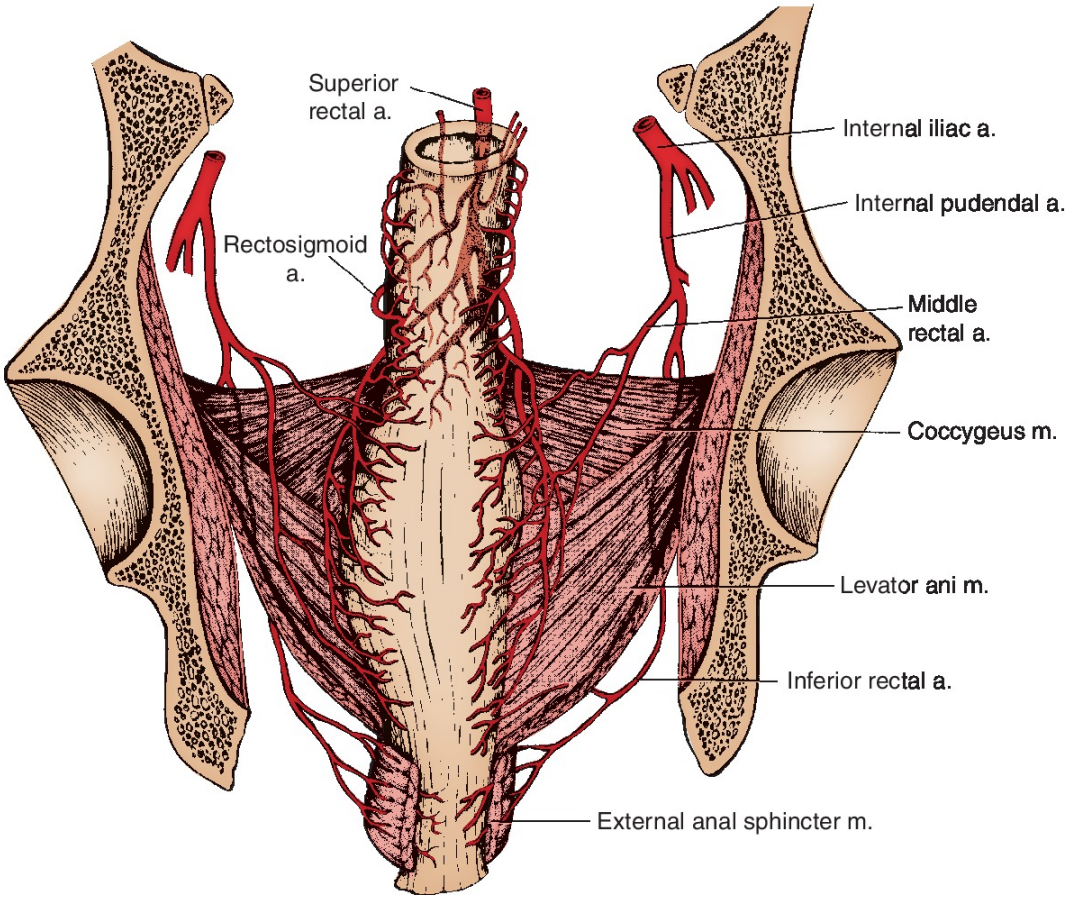


**FIGURE 1.26** The rectosigmoid colon and anal canal showing collateral arterial circulation from superior rectal (terminal

branch of inferior mesenteric), middle rectal (from internal iliac), and inferior anal (rectal), which are branches of the internal pudendal arteries (from internal iliac).

The external anal sphincter is innervated by the inferior anal (rectal) nerve, which can be a direct branch of the pudendal or arise independently from the sacral plexus. This nerve also provides cutaneous innervation to the perianal skin and distal part of anal canal to the level of the pectinate line. The internal anal sphincter is innervated by the inferior hypogastric plexus.

# PELVIC CONNECTIVE TISSUE

The “endopelvic fascia” is a term sometimes used to refer to both parietal fascia and extraperitoneal and visceral fascia in the abdomen and pelvis. However, the term “endopelvic fascia” remains controversial. The visceral pelvic fasciae (adventitial layers) of the pelvic viscera are continuous with condensations of irregular connective tissue on the lateral walls of the organs, which transmit vessels and nerves and blend with the thickenings of the connective tissues that lie over the pelvic wall muscles. These attachments, as well as the attachments of one organ to another, separate the different surgical cleavage planes from one another (**FIG. 1.27**). These condensations of the endopelvic fasciae surrounding the pelvic organs have assumed supportive roles, connecting the viscera to the pelvic walls, in addition to their role in transmitting the organs’ neurovascular supply from the pelvic wall. They are somewhat like a mesentery that connects the bowel, for example, to the body wall. They have a supportive function as well as a role in carrying vessels and nerves to the organ. An understanding of their disposition is important to both vaginal and abdominal surgeries.

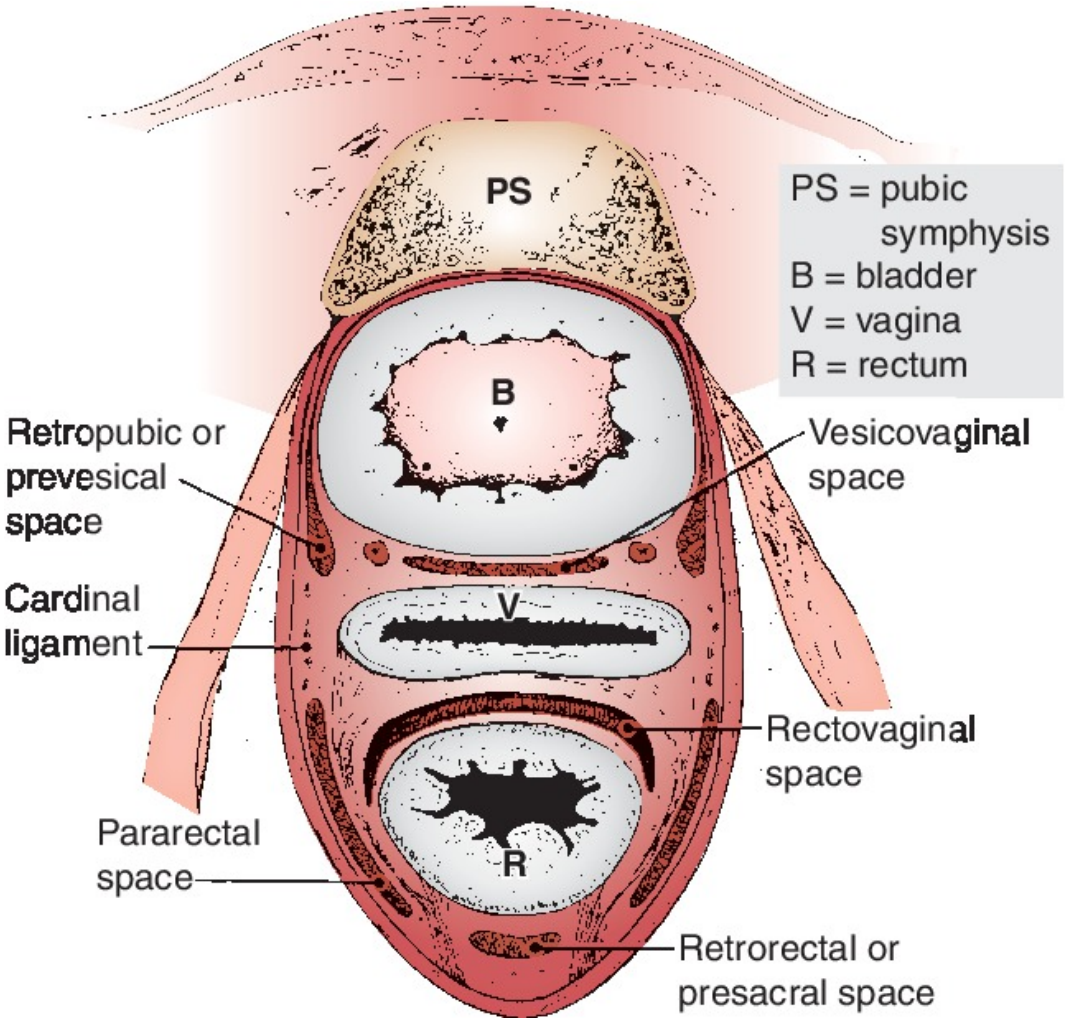


**FIGURE 1.27** Schematic cross section of the pelvis showing cleavage planes and spaces including the retropubic (prevesical), vesicovaginal, pararectal, rectovaginal, and retrorectal spaces.

The tissue that surrounds and connects the organs to the pelvic wall has been given the special designation of *endopelvic fascia*. It is not a layer similar to the layer encountered during abdominal incisions (rectus abdominis "fascia"). It is composed of blood vessels and nerves, interspersed with a supportive meshwork of irregular connective tissue containing collagen and elastin. These structures

connect the muscularis of the visceral organs to pelvic wall muscles. In some areas, there is considerable smooth muscle within this tissue, as is true in the area of the uterosacral ligaments. Although surgical texts often speak of this fascia as a specific structure separate from the viscera, this is not strictly true. These layers can be separated from the viscera, just as the superficial layers of the bowel wall can be artificially separated from the deeper layers, but they are not themselves separate structures.

The term *ligament* is most familiar when it describes a dense connective tissue band that links two bones, but it also describes ridges in the peritoneum or thickenings of the endopelvic fascia. The ligaments of the genital tract are diverse. Although they share a common designation (ie, ligament), they are composed of many types of tissue and have many different functions.

# Uterine Ligaments

The broad ligament comprises peritoneal folds that extend laterally from the uterus and cover the adnexal structures. They have no supportive function and were discussed in the section on the pelvic viscera.

At the base of the broad ligament, beginning just caudal to the uterine arteries, there is a thickening in the endopelvic fascia that attaches the cervix and upper vagina to the pelvic side walls (**FIG. 1.28**), consisting of the cardinal and uterosacral ligaments (parametrium and paracervix). Use of the term *ligament* has caused confusion over the years because it implies a separate structure that connects two bony structures. In fact, they are mesenteries that transmit vessels and nerves from the pelvic walls to the genital tract.

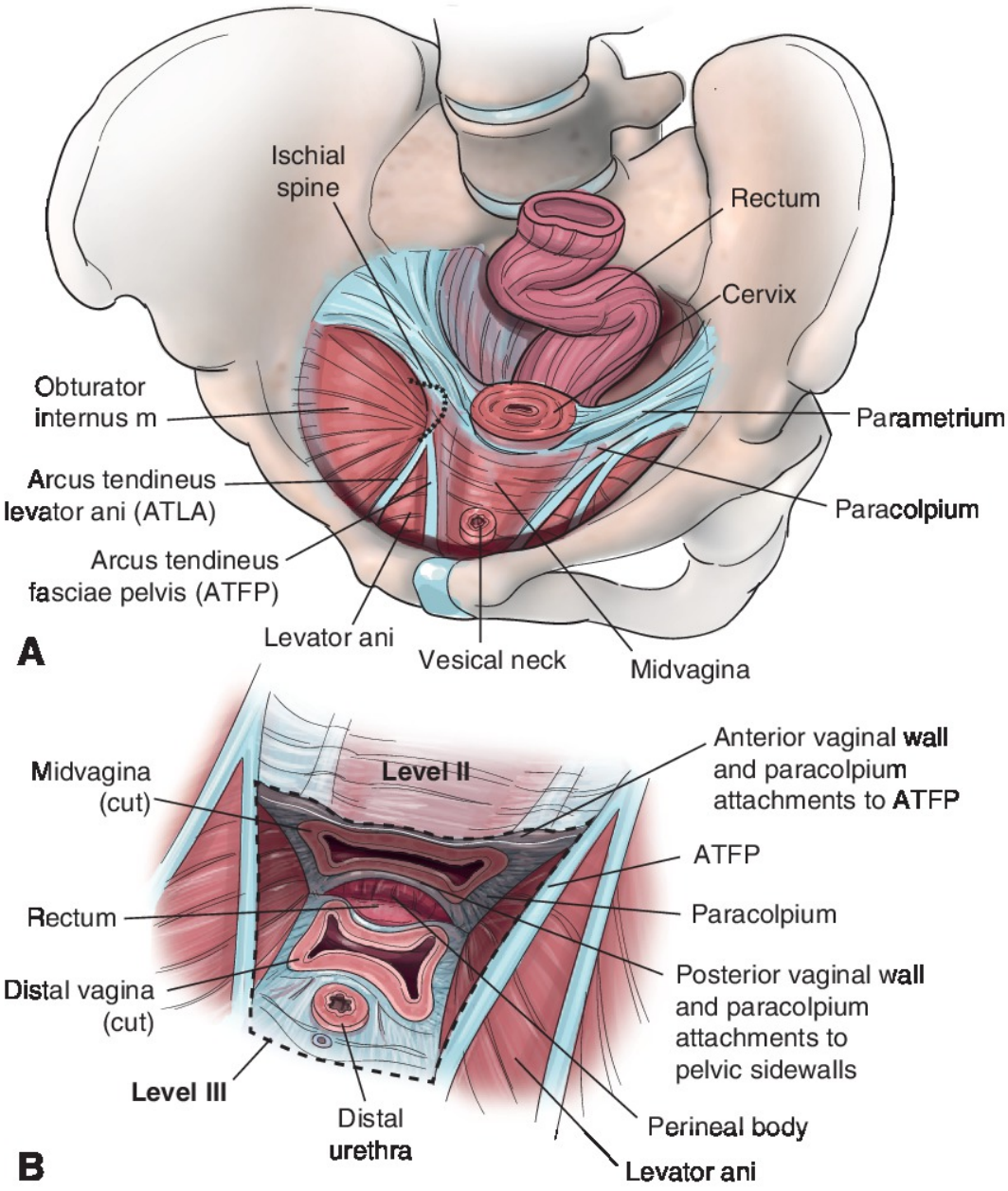


**FIGURE 1.28** **A.** Suspensory ligaments of the female genital tract as seen with the bladder removed. **B.** Close-up of the lower portion of the midvagina (level II) shows the lateral connective tissue attachments of the midvagina to the tendinous arch or the pelvic fascia. The cephalic surfaces of the

transected distal urethra and vagina (level III) are shown.

The term *uterosacral ligament* refers to that portion of this tissue that forms the medial and posterior margin of the parametrium and that borders the rectouterine pouch (cul-de-sac of Douglas). The term *cardinal ligament* is used to refer to that portion that attaches the lateral margins of the cervix and vagina to the pelvic walls. The course of the ureter as it forms a tunnel between the cardinal and uterosacral ligament forms a point of division between these two structures. The term *parametrium* refers to all the tissue that attaches to the uterus (both cardinal and uterosacral ligaments), and the term *paracolpium* is used to describe that portion that attaches to the vagina (cardinal ligament of the vagina).

The uterosacral ligament portion of the parametrium is composed predominantly of smooth muscle, the autonomic nerves of the pelvic organs, and some intermixed connective tissue and blood vessels, whereas the cardinal ligament portion consists primarily of perivascular connective tissue, nerves, and pelvic vessels. Although the cardinal ligaments are often described as extending laterally from the cervix to the pelvic wall, in the standing position, they are almost vertical as one would expect for a suspensory tissue. Near the cervix, the uterosacral ligaments are discrete, but they fan out in the retroperitoneal layer to have a broad, if somewhat ill-defined, area of attachment over the second, third, and fourth segments of the sacrum. The uterosacral ligaments hold the cervix posteriorly in the pelvis over the levator plate of the pelvic diaphragm.

The cardinal ligament lies at the lower edge of the broad ligament, between the peritoneal leaves, beginning just caudal to the uterine artery. The cardinal ligaments attach to the cervix below the isthmus and fan out to attach to the pelvic walls over the piriformis muscle in the area of the greater sciatic foramen. Although when placed under tension they feel like ligamentous bands, they are composed simply of perivascular connective tissue and nerves that surround the uterine and vaginal arteries and veins. Nevertheless, these structures have considerable strength. They provide support

not only to the cervix and uterus but also to the upper portion of the vagina (paracolpium) to keep these structures positioned posteriorly over the levator plate of the pelvic diaphragm and away from the urogenital hiatus. During radical pelvic surgery, the cardinal ligaments provide a surgical boundary between the anterior paravesical space and the posterior pararectal space.

## Vaginal Connective Tissue Attachments

The attachments of the vagina to the pelvic walls are important in maintaining the pelvic organs in their normal positions. Failure of these attachments, along with damage to the levator ani muscles, can result in various degrees of pelvic organ prolapse.

The layer that is dissected during anterior or posterior colporrhaphy is often referred to as the vaginal *fascia*. The term fascia has many meanings; in this case, the vaginal "fascia" is the muscularis of the vagina. Multiple histologic studies over the past 100 years have failed to show a true fascial layer between the bladder and vagina or vagina and rectum. Histologically, this layer has an abundance of connective tissue interspersed between the smooth muscle. Laterally, the mesenteric structures of the cardinal and uterosacral ligaments connect the vagina (and uterus) to the muscles and connective tissues that cover the lateral walls of the pelvis. The cardinal and uterosacral ligaments suspend these structures within the pelvis by their downward extension on the lateral margins of the genital tract (see **FIG. 1.28**).

The anterior vaginal compartment includes the anterior vaginal wall and its connective tissue (endopelvic fascia) attachments to pelvic sidewall at the tendinous arch of the pelvic fascia. Between the vagina and bladder is the vesicovaginal space and between the cervix and bladder is the vesicocervical space. These spaces are separated only by the attachment of the anterior vaginal wall to the cervix and by some augmented bands of connective tissue that attach the lower pole of the bladder to the anterior cervix and are often referred to as the supravaginal septum. Precise understanding

of this surgical anatomy is crucial for safe and proficient performance of anterior colpotomy during vaginal hysterectomy. A median dissection distance of ~3.4 cm is found from initial incision at the cervicovaginal junction to the anterior peritoneal reflection when performing anterior colpotomy for vaginal hysterectomy.

The posterior vaginal compartment is unique in its tissue composition and anatomic relationships to the adjacent anal sphincter complex, rectum, and rectouterine pouch (see **FIG. 1.29**). Loss of support of the posterior vaginal compartment can manifest as rectocele, enterocele, perineal bulge, or a combination of these findings. Clinical findings are partly explained by defect location and changes in associated muscle, connective tissue, and nerves. Various levels of vaginal support previously described provide a template for understanding the functional network involved in pelvic floor support of the posterior compartment. The upper third of the posterior vaginal wall is supported by the uterosacral ligaments and is bounded posteriorly by the cul-de-sac, described later. The rectovaginal space begins distal to the cul-de-sac peritoneum and extends inferiorly to the perineal body. Histologic analysis of this compartment shows a loose fibroadipose layer with slightly interspersed bands of fibrous tissue between the vagina and rectum. Descriptions of tissue composition between the vagina and rectum are variable but indicate a growing consensus that there is no true “rectovaginal fascia” or Denonvilliers fascia. Despite these histologic findings, the Terminologia Anatomica still includes the term “rectovaginal fascia.”

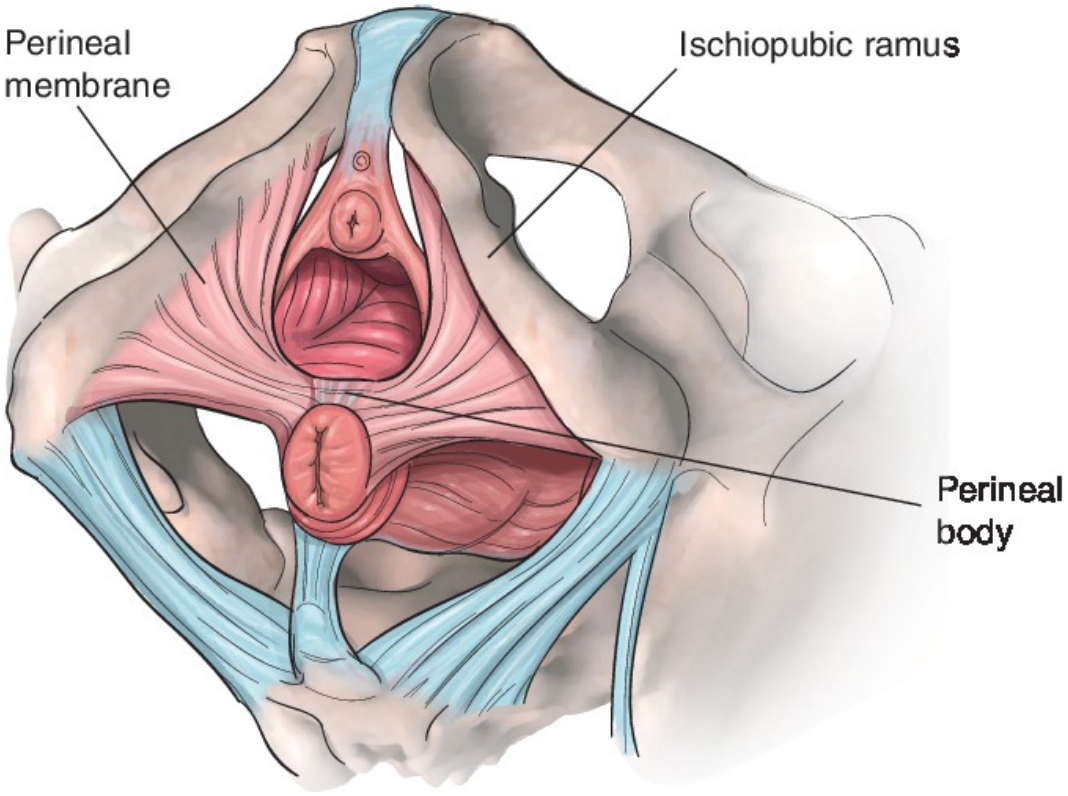


**FIGURE 1.29** The peripheral attachments of the perineal membrane to the ischiopubic rami and the perineal body.

The rectovaginal space can generally be effortlessly developed below the posterior peritoneal reflection for 4-5 cm to the level of the perineal body apex. Although no discrete separate fascial layer has been noted, lateral projections of vaginal adventitia to the endopelvic fascia, pelvic sidewall connective tissue, and levator ani muscles have been consistently observed. Therefore, the tissue plicated at the time of posterior colporrhaphy is likely derived from a splitting of the posterior vaginal wall (encompassing the muscularis and adventitia) and/or the anterior rectal wall. Gross examination can be misleading as manipulation of the tissue can artificially create a tissue layer that can be misconstrued as a separate fascial layer.

The distal third of the posterior vaginal wall is separated from the anal wall by the perineal body, which includes the anal sphincter

muscles. The perineal body histologically encompasses a central fibrous connection between the two halves of the perineal membrane, and it extends cranially for 2-3 cm above the hymenal ring. In this section, there is no plane of separation between the vaginal wall and anus histologically. Identifying loss of support at one or more vaginal segments (distal, mid, proximal) can help direct methods of surgical repair including perineorrhaphy, posterior colporrhaphy, or sacral colpoperineopexy.

# Urethral Support

The support of the proximal urethra plays a role in the maintenance of urinary continence during times of increased abdominal pressure. Although it is now known that stress incontinence is primarily caused by a weak urethral sphincter mechanism (low urethral closure pressure), urethral support does play an important, if secondary, role.

The distal portion of the urethra is inseparable from the vagina because of their common embryologic derivation from the urogenital sinus. These tissues are fixed firmly in position by connections of the periurethral tissues and vagina to the pubic bones through the perineal membrane. Cranial to this, beginning in the midurethra, a hammocklike layer composed of the endopelvic fascia and anterior vaginal wall provides the support of the proximal urethra (**FIG. 1.30**). This layer is stabilized by its lateral attachments to both the tendinous arch of pelvic fascia and the medial margin of the levator ani muscles. The muscular attachment of the endopelvic fascia allows contraction and relaxation of the levator ani muscles to elevate the urethra and to let it descend.

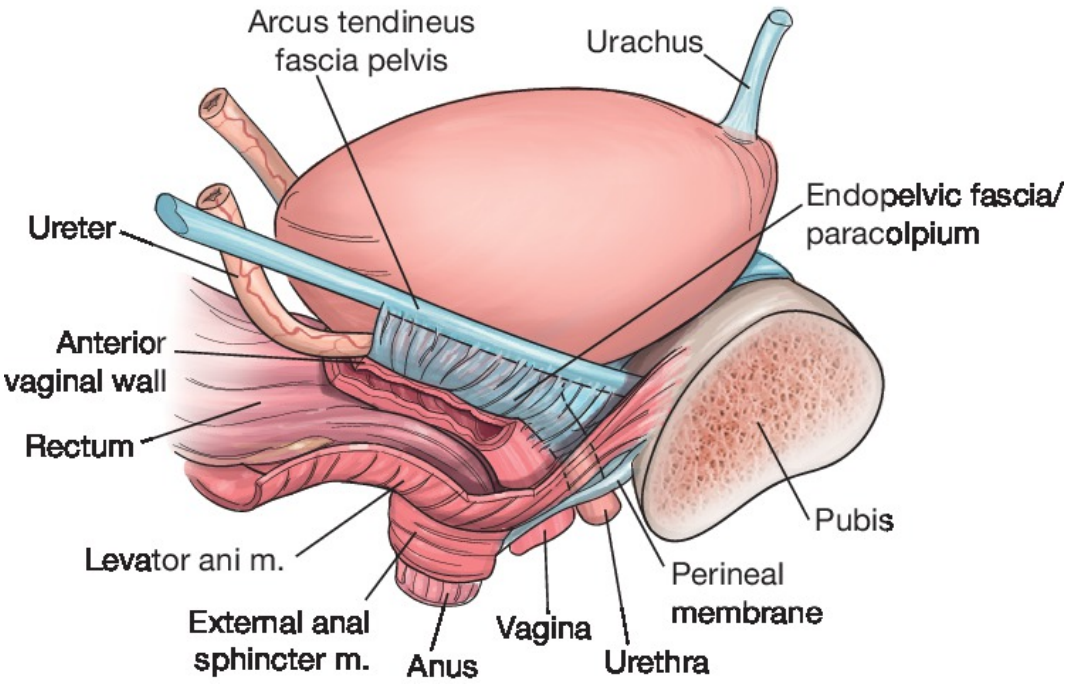


**FIGURE 1.30** Lateral view of the urethral supportive mechanism transected just lateral to the midline. The lateral wall of the vagina and a portion of the endopelvic fascia have been removed to expose or show the deeper structures.

It had previously been thought that the status of the urethral support system was the primary factor determining whether a woman had stress incontinence of urine. Recent studies have, however, shown that the strength of the urethral sphincter mechanism is the primary determining factor, with urethral support playing a secondary role. The way in which urethral support plays a role in continence can be understood as follows. During increases in abdominal pressure, the downward force caused by increased abdominal pressure on the ventral surface of the urethra compresses the urethra closed against the hammocklike supportive layer, thereby closing the urethral lumen. The stability of this supportive layer determines the effectiveness of this closure mechanism. If the layer is unyielding, it

forms a firm backstop against which the urethra can be compressed closed; however, if it is unstable, the effectiveness of this closure is compromised. Therefore, the integrity of the attachment to the tendinous arch of the fascia and the levator ani is critical to the stress continence mechanism.

# EXTRAPERITONEAL SURGICAL SPACES

It is an important property of the pelvic viscera that each can expand somewhat independently of its neighboring organs. The ability to do this comes from their relatively loose attachment to one another, which permits the bladder, for example, to expand without elongation of the adjacent cervix. This allows the viscera to be easily separated from one another along these lines of cleavage. These surgical cleavage planes are called spaces, although they are not empty but rather are filled with fatty or areolar connective tissue. The pelvic spaces are separated from one another by the connections of the viscera to one another and to the pelvic walls.

## Anterior and Posterior Cul-De-Sacs

Properly termed the *vesicouterine and rectouterine pouches*, the anterior and posterior cul-de-sacs separate the uterus from the bladder and rectum.

The anterior cul-de-sac is a recess between the dome of the bladder and the anterior surface of the uterus (**FIG. 1.31**). The peritoneum is loosely applied in the region of the anterior cul-de-sac, unlike its dense attachment to the upper portions of the uterine corpus. This allows the bladder to expand without stretching its overlying peritoneum. This loose peritoneum forms the vesicouterine fold, which can easily be lifted and incised to create a “bladder flap” during abdominal hysterectomy or cesarean section. It is the point at which the vesicocervical space is normally accessed during abdominal surgery and the peritoneal cavity entered during vaginal hysterectomy.

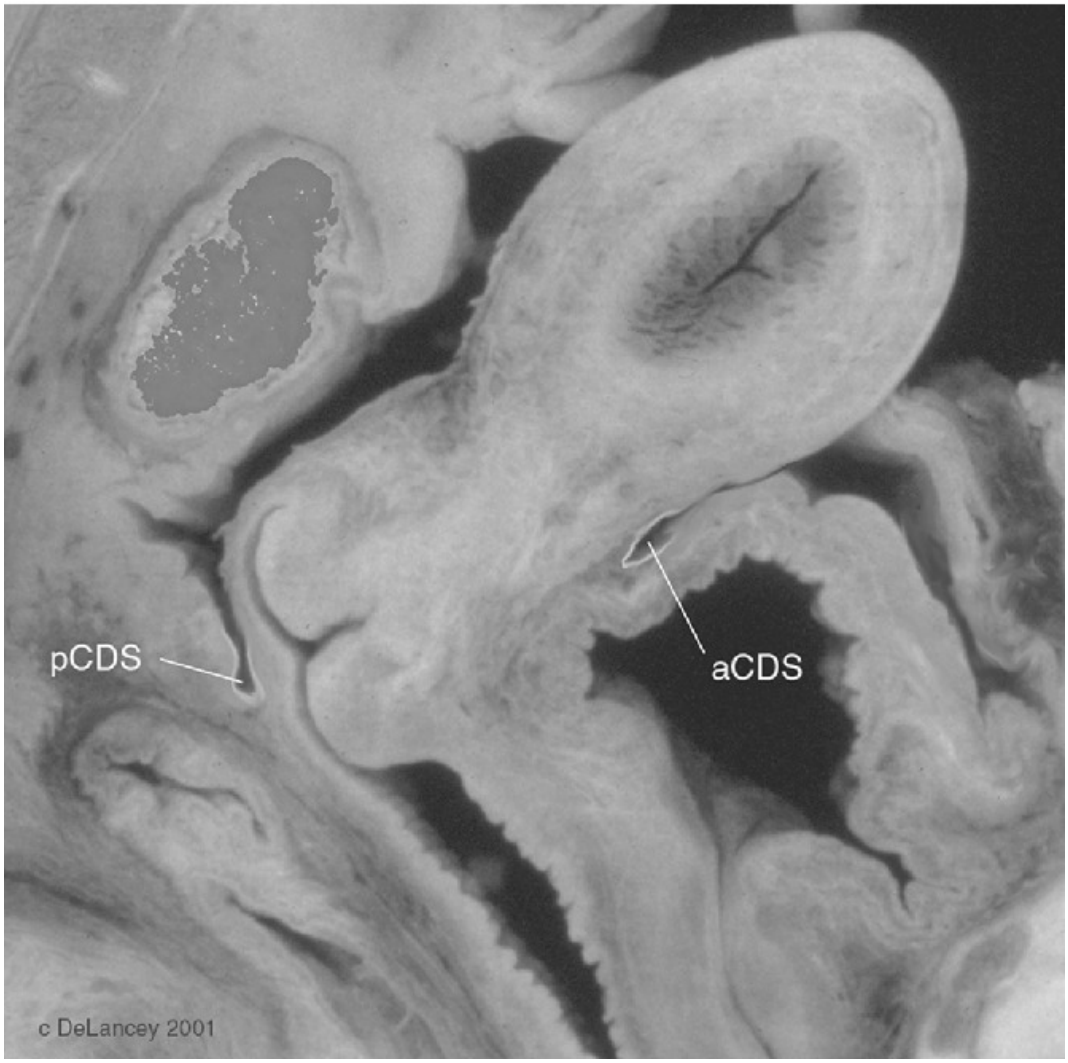


**FIGURE 1.31** Sagittal section from the cadaver of a 28-year-old woman showing the anterior cul-de-sac (*aCDS*) and the posterior cul-de-sac (*pCDS*). Note how the posterior cul-de-sac peritoneum lies on the vaginal wall, whereas the anterior cul-de-sac lies several centimeters from the cervicovaginal junction. (Peritoneum digitally enhanced in photograph to aid visibility.) (Copyright © 2001 John O. L. DeLancey, with permission.)

The posterior cul-de-sac is bordered by the vagina anteriorly, the rectum posteriorly, and the uterosacral ligaments laterally. Its peritoneum extends for ~4 cm along the posterior vaginal wall below the posterior vaginal fornix where the vaginal wall attaches to the cervix. This allows direct entry into the peritoneum from the vagina when performing a vaginal hysterectomy, culdocentesis, or colpotomy. The anatomy here contrasts with the anterior cul-de-sac described earlier. Anteriorly, the peritoneum lies several centimeters above the vagina, whereas posteriorly, the peritoneum covers the vagina. Keeping this anatomic difference in mind facilitates entering both the anterior and the posterior cul-de-sacs during vaginal hysterectomy, as described earlier.

# Retropubic/Prevesical Space

The retropubic space, also called the prevesical space or space of Retzius, is a potential surgical space filled with loose connective tissue that contains important neurovascular structures (see **FIG. 1.27**). It is separated from the undersurface of the rectus abdominis muscles by the transversalis fascia and can be entered by perforating this layer. Ventrolaterally, it is bounded by the bony pelvis and the muscles of the pelvic wall; cranially, it is bounded by the abdominal wall. The proximal urethra and bladder lie in a dorsal position. The dorsolateral limit to this space is the attachment of the bladder to the cardinal ligament and the attachment of the endopelvic fascia to the inner surface of the obturator internus and pubococcygeus and puborectalis muscles. These attachments to the tendinous arch of the pelvic fascia separate this space from the vesicovaginocervical space described earlier.

Important structures lying within this space include the dorsal veins of the clitoris that pass under the lower border of the pubic symphysis and the obturator nerve and vessels as they enter the obturator canal. Vascular connections between the external and internal iliac systems that pass over the superior pubic rami are commonly present. These are called pubic vessels or accessory obturator branches. The most common connections are venous and found between the inferior epigastrics and obturator veins, but these

vessels may arise directly from the external iliac. Therefore, dissection in this area should be performed with care. Lateral to the bladder and vesical neck is a dense plexus of vessels called the vesical venous plexus that lie at the border of the lower urinary tract. It includes two to five rows of veins that course within the paravaginal tissue parallel to the bladder and drain into the internal iliac veins. The dorsal veins of the clitoris drain into the vesical venous plexus. These veins course within paravaginal/paravesical tissue, and although they bleed when sutures are placed here, this venous ooze usually stops when the sutures are tied. Also within this tissue, lateral to the bladder and urethra, lie the nerves of the lower urinary tract. The upper border of the pubic bones that form the anterior surface of retropubic space has a ridgelike fold of periosteum called the pectineal line. This is used to anchor sutures during operations for stress incontinence (Burch procedure).

## Vesicovaginal and Vesicocervical Space

The space between the lower urinary tract and the genital tract is separated into the vesicovaginal and vesicocervical spaces (see **FIG. 1.27**). The lower extent of the space is the junction of the proximal one-third and distal two-thirds of the urethra, where the urethra and vagina are fused. This space extends superiorly to lie under the peritoneum at the vesicocervical peritoneal reflection. It extends laterally to the pelvic side walls, separating the vesical and genital aspects of the cardinal ligaments.

## Rectovaginal Space

On the dorsal surface of the vagina lies the rectovaginal space (see **FIG. 1.27**). It begins at the apex of the perineal body, about 2-3 cm above the hymenal ring. It extends upward to the cul-de-sac and laterally around the sides of the rectum to the attachment of the rectovaginal fascia (septum) to the parietal endopelvic fascia. It contains loose areolar tissue and is easily opened with finger dissection.

At the level of the cervix, some fibers of the cardinal-uterosacral ligament complex extend downward behind the vagina, connecting the vagina to the lateral walls of the rectum and then to the sacrum. These are called the rectal pillars. They separate the midline rectovaginal space in this region from the lateral pararectal spaces. These pararectal spaces allow access to the sacrospinous ligament (mentioned later). They also form the lateral boundaries of the retrorectal space between the rectum and sacrum.

## Region of the Sacrospinous Ligament and Greater Sciatic Foramen

The area around the sacrospinous ligament is another region that has become more important to the gynecologist operating for problems of vaginal support. The sacrospinous ligament lies on the dorsal aspect of the ischiococcygeus (coccygeus) muscle (**FIG. 1.15 and 1.32**). The ligament with overlying muscle contributes to the posterior and inferior boundary of the pararectal space.

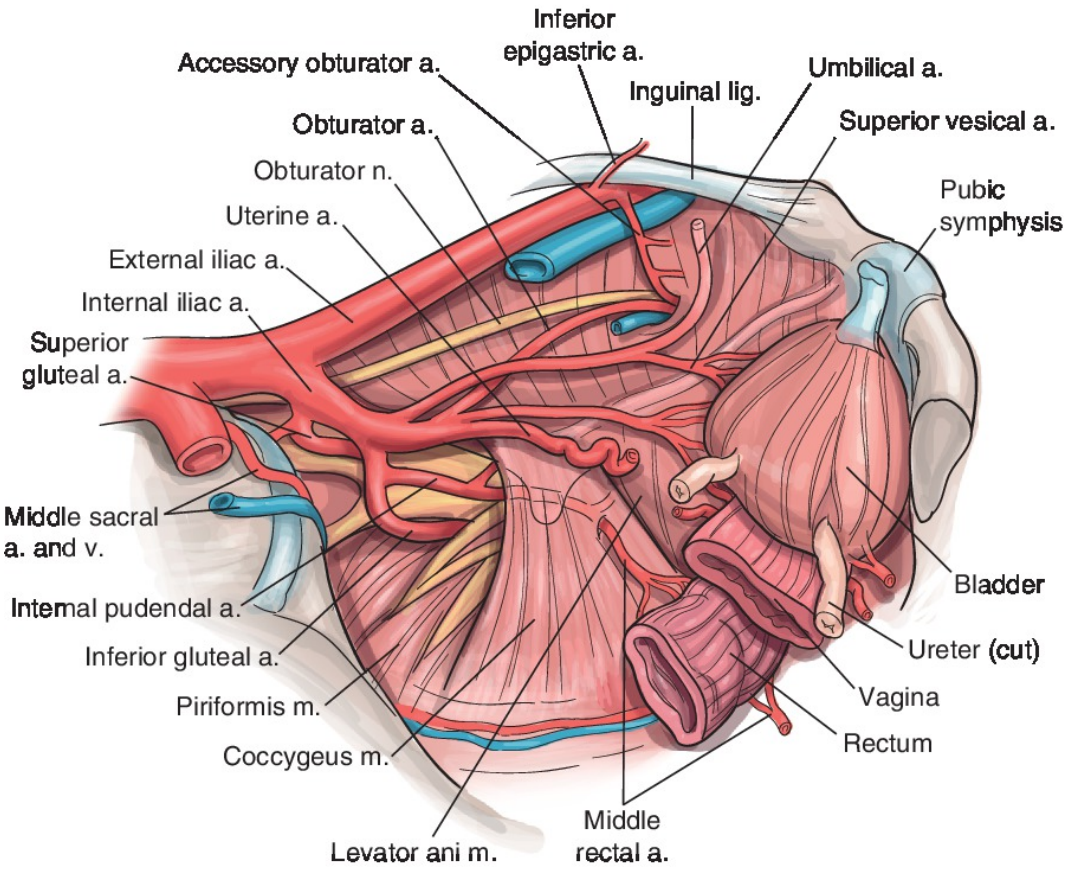


**FIGURE 1.32** Structures of the pelvic side wall.

As its name implies, the sacrospinous ligament courses from the lateral aspect of the sacrum to the ischial spine. In its medial portion, it fuses with the sacrotuberous ligament and is a distinct structure only laterally. It can be reached from the rectovaginal space by perforation of the rectal pillar to enter the pararectal space or by dissection directly under the enterocele peritoneum. It can also be reached from the paravesical space. The nerve to the coccygeus and the levator ani nerve, both from S3-S5, are associated with the anterior surface of muscle-ligament complex.

Many structures are near the sacrospinous ligament, and their location must be remembered during surgery in this region. The sacral plexus lies cephalad to the ligament on the inner surface of the piriformis muscle, and its major branch, the sciatic nerve, leaves

the pelvis through the lower part of the greater sciatic foramen. The sacral plexus supplies nerves to the muscles of the hip, pelvic diaphragm, and perineum, as well as to the lower leg (through the sciatic nerve). Just before it exits through the greater sciatic foramen, the sacral plexus gives off the pudendal nerve, which, with its accompanying vessels, passes posterior to the sacrospinous ligament close to the ischial spine. The nerve to the levator ani muscles, which arises from S3-S5 fibers, passes over the midportion of the coccygeus muscle to supply the levator muscles. The nerve to the coccygeus muscles also arises from S3-S5 nerves and perforates this muscle from its pelvic surface. In developing this space, the tissues that are reflected medially and cranially to gain access contain the pelvic venous plexus of the internal iliac vein, as well as the middle rectal vessels. If they are mobilized too vigorously, they can cause considerable hemorrhage. The internal pudendal and inferior gluteal vessels and the third sacral nerve and pudendal nerve are associated with the superior margin of the sacrospinous ligament and can be injured if the exit or entry point of a needle extends above the upper extent of the ligament. The internal pudendal artery passes behind the lateral third of the ligament, and the inferior gluteal exits the greater sciatic foramen at the mid ligament level, usually by passing between the second and third sacral nerves. The third sacral nerve and pudendal nerve course just above and almost parallel to the upper margin of the ligament. The small fourth sacral nerve passes over the medial surface of the ligament to join the third sacral nerve in forming the pudendal nerve (see **FIG. 1.15**).

# RETROPERITONEAL SPACES AND LATERAL PELVIC WALL

The retroperitoneal space contains the major neural, vascular, and lymphatic supply to the pelvic viscera. This space may be explored during operations to identify the ureter, interrupt the pelvic nerve supply, arrest serious pelvic hemorrhage, and remove potentially malignant lymph nodes. Because this area is generally free of the

adhesions from serious pelvic infection or endometriosis, it can be used as a plane of dissection when the peritoneal cavity has become obliterated. The structures found in these spaces are discussed in a regional context, because that is the way they are usually approached in the operating room.

## Retroperitoneal Structures Above the Pelvic Brim

The abdominal aorta lies on the lumbar vertebrae slightly to the left of the vena cava, which it partially overlies. The renal blood vessels arise at the second lumbar vertebral level. The left renal vein passes on the anterior surface of abdominal aorta, just below the superior mesenteric artery. Below the renal vessels, the aorta and vena cava are encountered during retroperitoneal dissection of the para-aortic lymph nodes (**FIG. 1.33**). The ovarian vessels also arise from the anterior surface of the aorta in this region, just below the renal vessels. In general, the branches of the vena cava follow those of the aorta, except for the vessels of the intestine, which flow into the portal vein, and the left ovarian vein, which empties into the renal vein on that side.

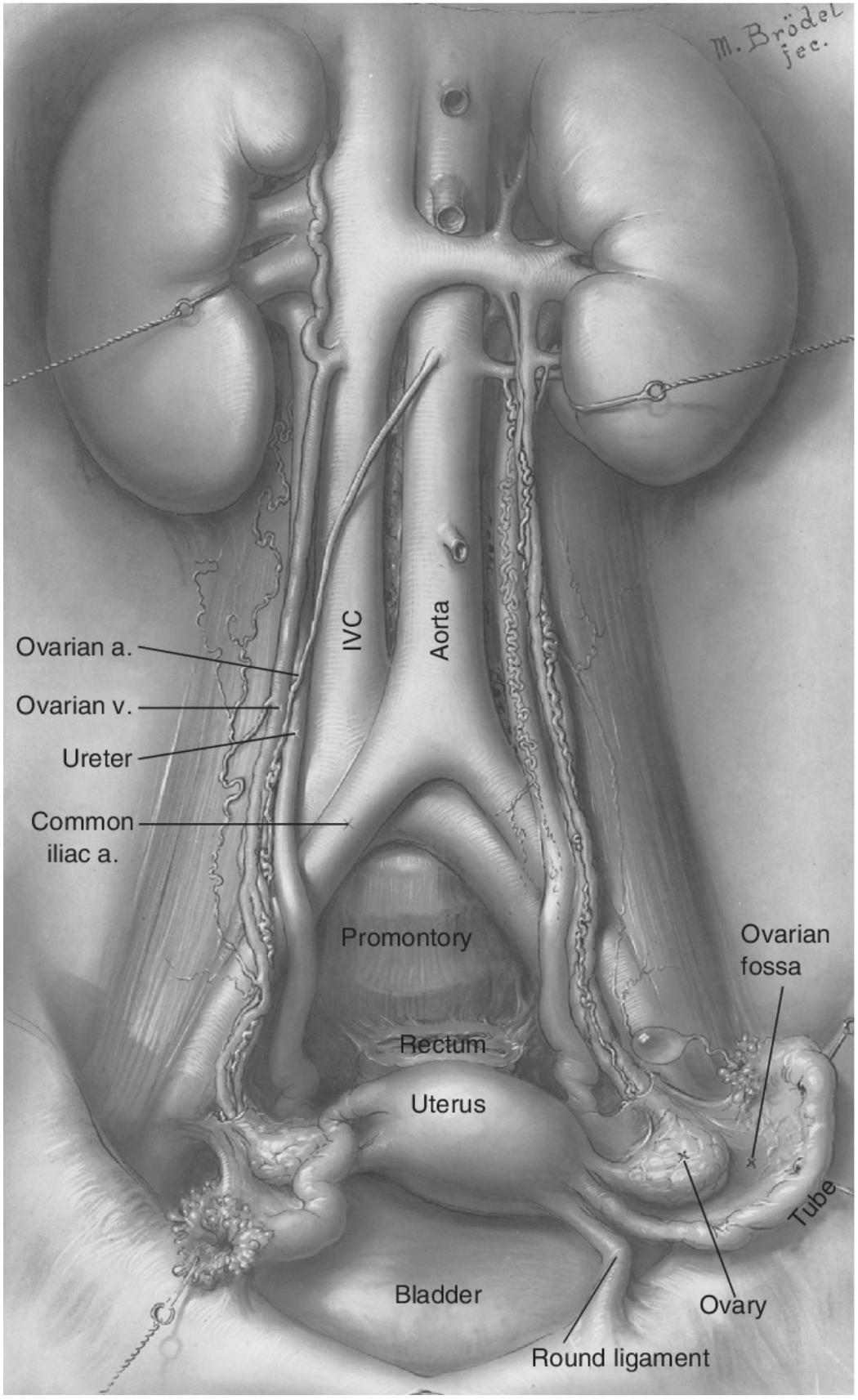
M. Brödel jec.
IVC
Aorta
Ovarian a.
Ovarian v.
Ureter
Common iliac a.
Promontory
Ovarian fossa
Rectum
Uterus
Tube
Bladder
Ovary
Round ligament

**FIGURE 1.33** Course of the ureter and structures of the retroperitoneum. Note the anomalous origin of the left ovarian artery from the left renal artery rather than from the aorta. (The original illustration is in the Max Brödel Archives in the Department of Art as Applied to Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA. Used with permission.)

The inferior mesenteric artery arises from the anterior aorta below the level of the renal vessels and just below the third portion of the duodenum, approximately at the third lumbar vertebral level. It supplies the distal third of the transverse colon, descending colon, sigmoid colon, and rectum. It gives off ascending branches of the left colic artery and continues caudally to supply the sigmoid through the three or four sigmoid arteries that lie in the sigmoid mesentery. These vessels follow the bowel as it is pulled from side to side, so that their position can vary, depending on retraction.

The superior rectal artery is the terminal continuation of the inferior mesenteric artery. This vessel crosses over the left external iliac vessels to lie on the dorsum of the lower sigmoid. It supplies the rectum, as described in the section concerning that viscus.

The aorta and vena cava have segmental branches that arise at each lumbar level and are called the lumbar arteries and veins. They are situated somewhat posteriorly to the aorta and vena cava and are not visible from the front. When the vessels are mobilized, as is done in excising the lymphatic tissue in this area, they come into view.

At the level of the fourth lumbar vertebra, just below the umbilicus, the aorta bifurcates into the left and right common iliac arteries. After about 5 cm and approximately at the level of the sacroiliac joint, the common iliac arteries (and the medially and

posteriorly placed veins) give off the internal iliac vessels from their medial side and continue toward the inguinal ligament as the external iliac arteries. The internal iliac vessels lie within the pelvic retroperitoneal region and are discussed later.

The external iliac vessels have a consistent course on the medial surface of psoas major muscles. Shortly before these vessels pass under the inguinal ligament to become the femoral vessels, they give up the inferior epigastric and deep circumflex iliac vessels. The deep circumflex iliac vein usually passes over the external iliac artery and is often used as a landmark for the caudal limit of external iliac lymphadenectomy.

The aorta and vena cava are surrounded by lymph nodes on all sides. Surgeons usually refer to this lumbar chain of nodes as the para-aortic nodes, reflecting their position. They receive the drainage from the common iliac nodes and are the final drainage of the pelvic viscera. In addition, they collect the lymphatic drainage from the ovaries that follows the ovarian vessels and does not pass through the iliac nodes. The nodes of the lumbar chain extend from the right side of the vena cava to the left of the aorta and can be found both anterior and posterior to the vessels.

Above the pelvic brim, the ureters are attached loosely to the posterior abdominal wall, and when the overlying colon is mobilized, they remain on the body wall. They are crossed anteriorly by the ovarian vessels, which contribute a branch to supply the ureter. Additional blood supply to the abdominal portion comes from the renal vessels and the common iliac artery.

# Presacral Space

The presacral space begins below the bifurcation of the aorta and is bounded laterally by the common and internal iliac arteries (**FIGS. 1.34 and 1.35**). It extends inferiorly to the superior fascia of the levator muscles and midline iliococcygeal raphe. The rectum and peritoneum form the anterior boundary; the lower lumbar vertebra, sacrum, and overlying anterior longitudinal ligament bound the space posteriorly. Lying directly on the sacrum are the median sacral artery and vein. The artery originates from the dorsal aspect of the distal

aorta (and not from the point of bifurcation, as sometimes shown). The vein(s) drains into the left common iliac vein or vena cava. Caudal and lateral to this are the lateral sacral vessels, which drain into the internal iliac vein. The sacral venous plexus is formed primarily by these vessels but also receives contributions from the lumbar veins of the posterior abdominal wall and from the basivertebral veins that pass through the pelvic sacral foramina. The basivertebral veins are thin-walled vessels contained in large, tortuous channels in the cancellous tissue of the bodies of the vertebrae. The sacral venous plexus formed by these vessels can be extensive, and bleeding from it can be considerable.

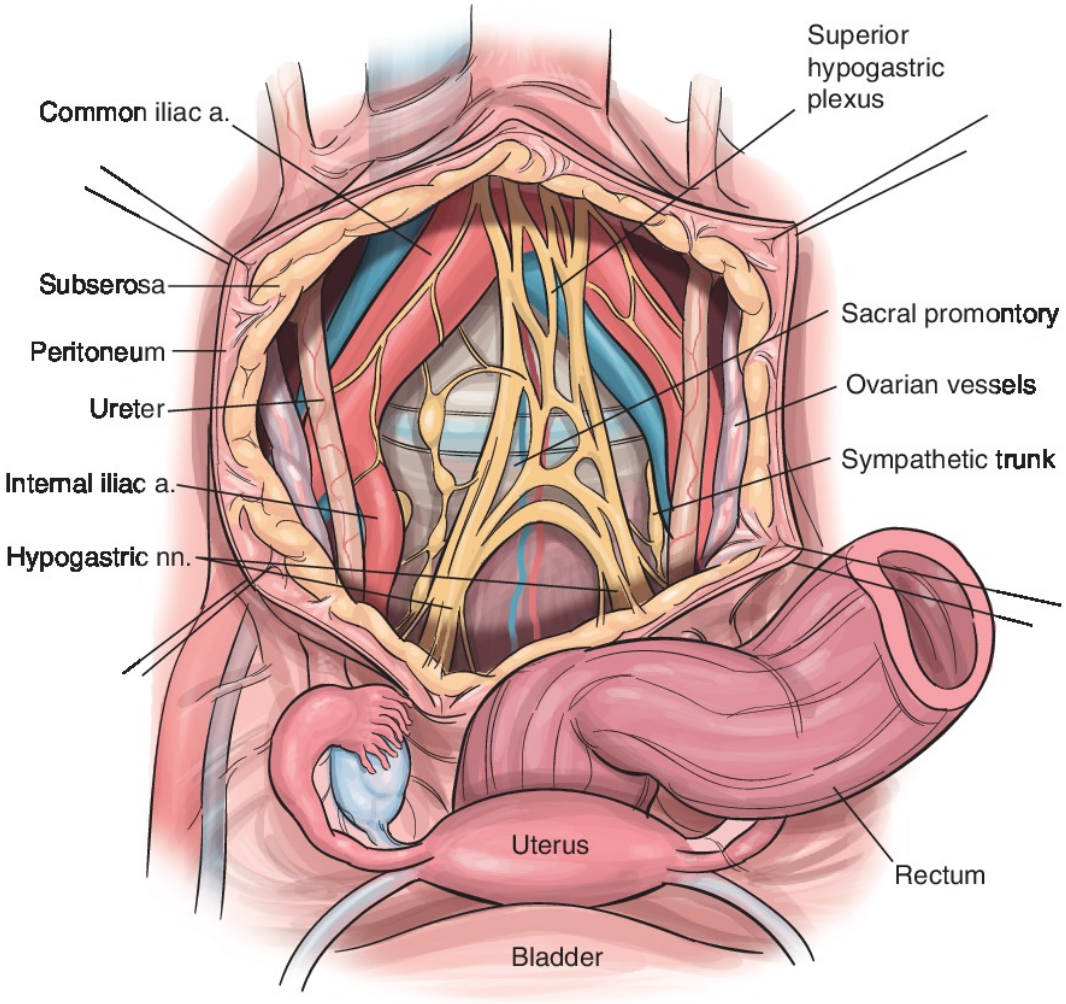

**FIGURE 1.34** Superior hypogastric plexus, showing the passage of this plexus over the bifurcation of the aorta. Observe the division of the plexus into left and right hypogastric nerves.

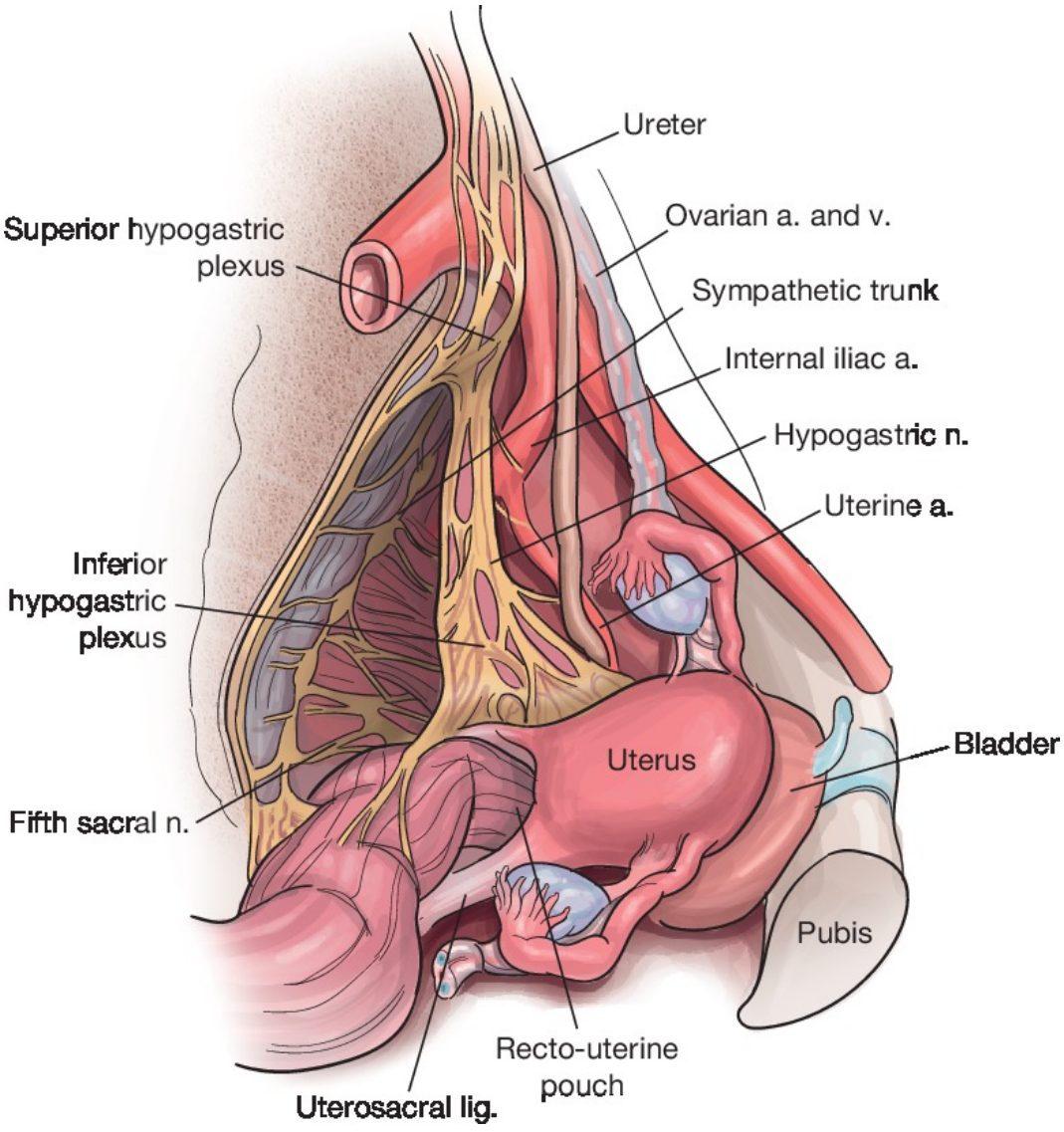


**FIGURE 1.35** Inferior hypogastric plexus.

The sacral promontory represents the most superior aspect of the anterior surface of the first sacral vertebra and is a common bony landmark used during surgeries such as sacrocolpopexy, presacral neurectomy, and lymph node dissection. Great variability in the lumbosacral anatomy and fat content in the presacral space may impede precise identification of this bony landmark. The ureters and common iliac and internal iliac vessels all lie within 3 cm from the midpoint of the promontory. The closest major vessel to the midsacral promontory is usually the left common iliac vein. The fifth lumbar to first sacral intervertebral disk is found just above the sacral promontory and is generally the most visible nonvascular structure noted intraoperatively.

Within this area lies the most familiar part of the pelvic autonomic nervous system, the superior hypogastric plexus or presacral nerve (see **FIG. 1.34**). The autonomic nerves of the pelvic viscera can be divided into a sympathetic (thoracolumbar) and a parasympathetic system. The parasympathetic part of the autonomic division in the pelvis arises from the second through the fourth sacral nerve segments and is called the parasympathetic root (pelvic splanchnic nerves). The former is also called the adrenergic system, and the latter is called the cholinergic system, according to their neurotransmitters. α-Adrenergic stimulation causes increased urethral and vesical neck tone, and cholinergic stimulation increases contractility of the detrusor muscle. Similarly, adrenergic stimulation in the colon and rectum favors storage, and cholinergic stimulation favors evacuation. β-Adrenergic agonists, which are used for tocolysis, suggest that these influence contractility of the uterus. As is true in the man, damage to the autonomic nerves during pelvic lymphadenectomy can have a significant influence on orgasmic function in the woman. Variable degrees of voiding and defecation dysfunction are also common following radical pelvic surgeries.

How these autonomic nerves reach the organs that they innervate has surgical importance. The terminology of this area is somewhat confusing, because many authors use idiosyncratic terms. However, the structure is simple: a single ganglionic midline plexus overlies the lower aorta (superior hypogastric plexus). This plexus splits into two trunks without ganglia (hypogastric nerves), each of

which connects with a plexus of nerves and ganglia lateral to the pelvic viscera known as the inferior hypogastric plexus (**FIG. 1.35**).

The superior hypogastric plexus lies in the retroperitoneal connective tissue on the ventral surface of the lower aorta and receives input from the sympathetic chain ganglia through the thoracic and lumbar splanchnic nerves. It also contains important afferent pain fibers from the pelvic viscera, which makes its transection sometimes effective in primary dysmenorrhea. It passes over the bifurcation of the aorta and extends over the proximal sacrum before splitting into two hypogastric nerves that descend into the pelvis toward the region of the internal iliac vessels. On each side of the pelvis, the hypogastric nerves end in the inferior hypogastric plexus.

The inferior hypogastric plexuses are broad expansions of the hypogastric nerves. Their sympathetic fibers come from the downward extensions of the superior hypogastric plexus and from the sacral splanchnic nerves, a continuation of the sympathetic chain or trunk into the pelvis. Parasympathetic fibers come from sacral segments two through four by way of the parasympathetic root of the pelvic ganglia (pelvic splanchnic nerves). They lie in the pelvic connective tissue of the lateral pelvic wall, lateral to the uterus and vagina.

The inferior hypogastric plexus (sometimes called the pelvic plexus) is divided into three portions: the vesical plexus, the uterovaginal plexus (Frankenhäuser ganglion), and the middle rectal plexus. The uterovaginal plexus contains fibers that derive from two sources. It receives sympathetic and sensory fibers from the 10th thoracic through the first lumbar spinal cord segments. The second input comes from the second, third, and fourth sacral segments and consists primarily of parasympathetic nerves that reach the inferior hypogastric plexus through the pelvic splanchnic nerves. The uterovaginal plexus lies on the dorsal and medial surface of the uterine vessels, lateral to the uterosacral (rectouterine) ligaments' insertion into the uterus. It has continuations cranially along the uterus and caudally along the vagina. These latter extensions contain the fibers that innervate the vestibular bulbs and clitoris and are called the cavernous nerve of the clitoris. These nerves lie in the

tissue just lateral to the area where the uterine artery, cardinal ligament, and uterosacral ligament pedicles are made during a hysterectomy for benign disease and within the tissue removed during a radical hysterectomy.

The sensory fibers from the uterine body in the superior hypogastric plexus (the presacral nerve) have sometimes been surgically transected in an effort to alleviate refractory visceral pain from the corpus, a procedure called presacral neurectomy. As the superior hypogastric plexus does not provide sensory innervation to the adnexal structures or to the peritoneum, this procedure is therefore not useful for alleviating pain arising from those sites. Another important anatomic aspect of the autonomic nervous system is damage to the inferior hypogastric plexus at the time of radical hysterectomy. The extension of the surgical field lateral to the viscera interrupts the connection of the bladder and sometimes the rectum to their central attachments.

The ovary and uterine tube receive their neural supply from the plexus of nerves that accompany the ovarian vessels and that originate in the renal plexus and partly from the inferior hypogastric plexus. These fibers originate from the 10th thoracic segment, and the parasympathetic fibers come from extensions of the vagus nerve.

# Pelvic Retroperitoneal Space

Division of the internal and external iliac vessels occurs in the area of the sacroiliac joint. The course and branches of the external iliac vessels were discussed earlier under the retropubic space.

## *Internal Iliac Vessels*

Unlike the external iliac artery, which is constant and relatively simple in its morphology as discussed earlier, the branching pattern of the internal iliac arteries and veins is extremely variable (**FIGS. 1.11 and 1.36**). The internal iliac artery supplies the viscera of the pelvis and many muscles of the pelvic wall and gluteal region. It usually divides into an *anterior* and *posterior* division about 3-4 cm

after leaving the common iliac artery. The vessels of the posterior division (the iliolumbar, lateral sacral, and superior gluteal) leave the internal iliac artery from its posterolateral surface to provide some of the blood supply to the pelvic wall and gluteal muscles. Trauma to these hidden vessels should be avoided during internal iliac artery ligation (**TABLE 1.3**) as the suture is passed around behind vessels.

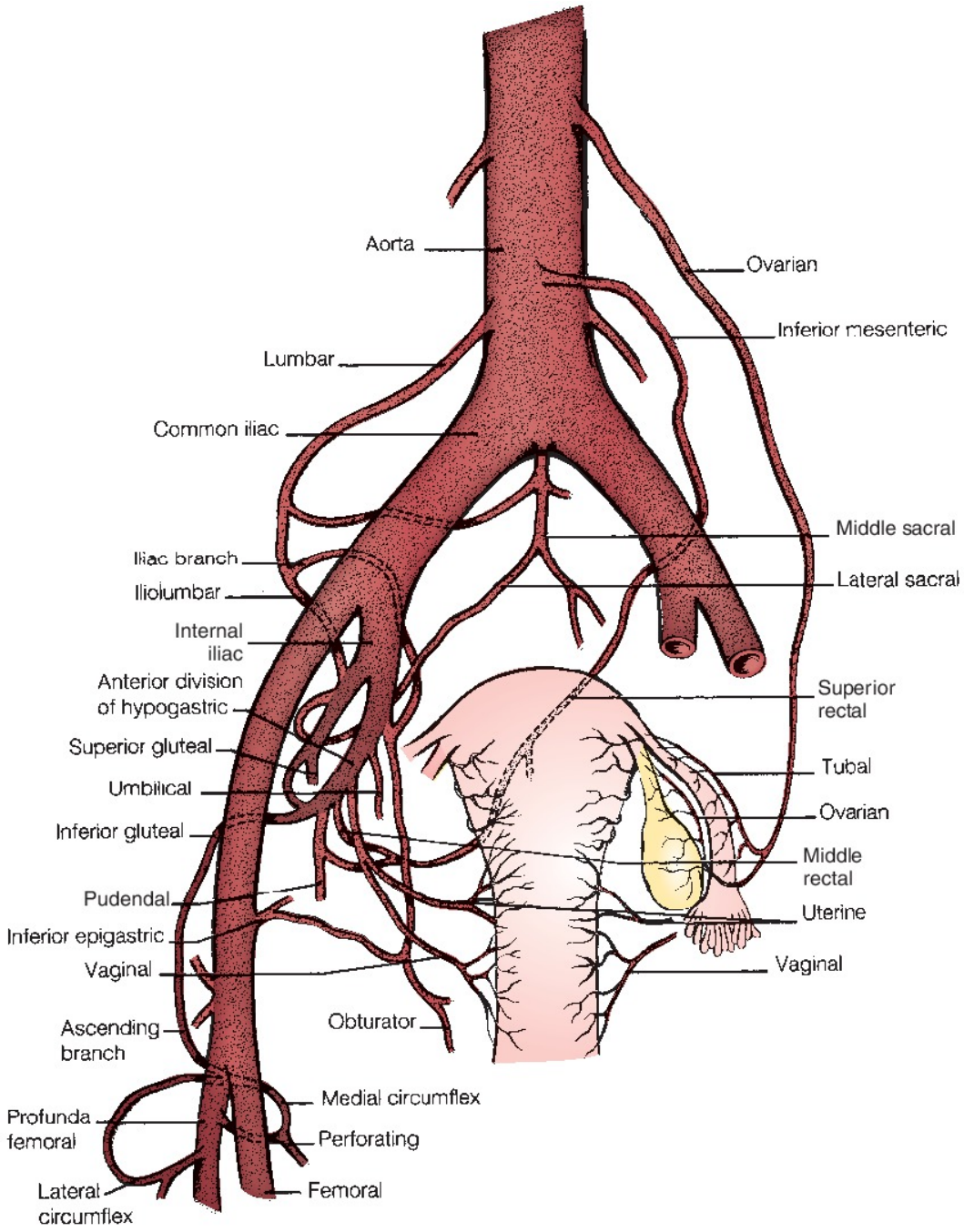

**FIGURE 1.36** Collateral circulation of the pelvis.

## TABLE 1.3
## Collateral Circulation After Internal Iliac Artery Ligation

| |
|---|
| Internal iliac and systemic (aortic) anastomosis |
| Iliolumbar and lumbar |
| Lateral sacral and middle sacral |
| Middle rectal and superior rectal (terminal continuation of inferior mesenteric) |

The anterior division has three parietal and several visceral branches that supply the pelvic viscera. The obturator, internal pudendal, and inferior gluteal vessels primarily supply the muscles, whereas the uterine, superior vesical, vaginal (inferior vesical), and middle rectal vessels supply the pelvic organs. The internal iliac veins begin lateral and posterior to the arteries. These veins form a large and complex plexus within the pelvis, rather than having single branches, as do the arteries. They tend to be deeper in this area than the arteries, and their pattern is highly variable.

Ligation of the internal iliac artery has proved helpful in the management of postpartum hemorrhage. Burchell's arteriographic studies showed that physiologically active anastomoses between the systemic and pelvic arterial supplies were immediately patent after ligation of the internal iliac artery (see **FIG. 1.36**). These anastomoses, shown in **TABLE 1.3**, connected the arteries of the internal iliac system with blood vessels either directly from the aorta (eg, the lumbar and middle sacral artery) or indirectly through the inferior mesenteric artery (eg, superior rectal vessels). These *in vivo* pathways were quite different from the anastomoses that had previously been hypothesized on purely anatomic grounds.

## *Pelvic Ureter*

The course of the ureter within the pelvis is important to gynecologic surgeons and is fully considered in Chapter 37. A few of the important anatomic landmarks are considered here. After passing over the bifurcation of the internal and external iliac arteries, just medial to the ovarian vessels, the ureter descends within the pelvis. Here, it lies in a special connective tissue sheath that is attached to the peritoneum of the lateral pelvic wall and medial leaf of the broad ligament. This explains why the ureter still adheres to the peritoneum and does not remain laterally with the vessels when the peritoneal space is entered.

The ureter crosses under the uterine artery ("water flows under the bridge") at the base of the broad ligament, just before it enters the cardinal ligament. There is a loose areolar plane around it to allow for its peristalsis as it courses through the "tunnel" within the cardinal ligament fibers. In this region, it lies along the anterolateral surface of the cervix, usually 1-2 cm from it. From there, it comes to lie on the anterior vaginal wall and then proceeds for a distance of about 1.5 cm through the wall of the bladder.

During its pelvic course, the ureter receives blood from the vessels that it passes, specifically the common iliac, internal iliac, uterine, and vesical arteries. Within the wall of the ureter, these vessels are connected to one another by a convoluted network of vessels that can be seen running longitudinally along its outer surface.

# Lymphatics

The lymph nodes and lymphatic vessels that drain the pelvic viscera vary in their number and distribution, but they can be organized into coherent groups. Because of the extensive interconnection of the lymph nodes, spread of lymph flow, and thus malignancy, is somewhat unpredictable. However, some important generalizations about the distribution and drainage of these tissues are still helpful. The distribution of pelvic lymph nodes is discussed further in Chapter 27 and illustrated in Figure 27.6A.

The nodes of the pelvis can be divided into the external iliac, internal iliac, common iliac, medial sacral, and pararectal nodes. The medial sacral nodes are few and follow the median sacral artery. The pararectal nodes drain the part of the rectosigmoid above the peritoneal reflection that is supplied by the superior rectal artery. The median and pararectal nodes are seldom involved in gynecologic disease.

The internal and external iliac nodes lie next to their respective blood vessels, and both end in the common iliac chain of nodes, which then drain into the nodes along the aorta. The external iliac nodes receive the drainage from the leg through the inguinal nodes. Nodes in the external iliac group can be found lateral to the artery, between the artery and vein, and on the medial aspect of the vein. These groups are called the anterosuperior, intermediate, and posteromedial groups, respectively. They can be separated from the underlying muscular fascia and periosteum of the pelvic wall along with the vessels, thereby defining their lateral extent. Some nodes at the distal end of this chain lie in direct relation to the inferior epigastric vessels and are named according to these adjacent vessels. Similarly, nodes that lie at the point where the obturator nerve and vessels enter the obturator canal are called obturator nodes.

The internal iliac nodes drain the pelvic viscera and receive some drainage from the gluteal region along the posterior division of the internal iliac vessels as well. These nodes lie within the adipose tissue that is interspersed among the many branches of the vessels. The largest and most numerous nodes lie on the lateral pelvic wall, but many smaller nodes lie next to the viscera themselves. These nodes are named for the organ by which they are found (eg, parauterine).

Not only is it difficult in the operating room to make some of the fine distinctions mentioned in this anatomic discussion but also there is little clinical importance in doing so. Surgeons generally refer to those nodes that are adjacent to the external iliac artery as the external iliac group of nodes and to those next to the internal iliac artery as the internal iliac nodes. This leaves those nodes that lie

between the external iliac vein and internal artery, which are called interiliac nodes.

The direction of lymph flow from the uterus tends to follow its attachments, draining along the cardinal, uterosacral, and even round ligaments. This latter connection can lead to metastasis from the uterus to the superficial inguinal nodes, whereas the former connections are to the internal iliac nodes, with free communication to the external iliac nodes and sometimes to the lateral sacral nodes. The anastomotic connection of the uterine and ovarian vessels makes lymphatic connections between these two drainage systems likely and metastasis in this direction possible.

The vagina and lower urinary tract have a divided lymphatic drainage. Superiorly (upper two-thirds of the vagina and the bladder), drainage occurs along with the uterine lymphatics to the internal iliac nodes, whereas the lower one-third of the vagina and distal urethra drain to the inguinal nodes. However, this demarcation is far from precise.

The common iliac nodes can be found from the medial to the lateral border of the vessels of the same name. They continue above the pelvic vessels and occur around the aorta and the vena cava. These nodes can lie anterior, lateral, or posterior to the vessels.

# KEY POINTS

- Important anatomic relationships of the pelvic ureter include the following:
  - The ureter lies medial to the ovarian vessels at the bifurcation of the internal and external iliac arteries at the level of the pelvic brim.
  - The ureter descends in the pelvis attached to the medial leaf of the broad ligament.
  - Because of its medial course on the inner surface of the pelvic sidewall peritoneum, blood supply reaches the ureter from laterally located vessels.

- The ureter courses under the uterine artery at ~1-2 cm lateral to the cervix.
- The distal ureter lies directly on the anterior vaginal wall, very near the site where the vagina is detached from the cervix during a hysterectomy. Thus, sufficient mobilization and retraction of the bladder from the anterior vagina are critical to avoid injury.

- The ilioinguinal and iliohypogastric nerves course in the region of the anterior abdominal wall involved in lower abdominal transverse incisions and insertion of accessory trocars and can be involved with nerve entrapment syndromes. This risk is reduced if lateral trocars are placed superior to the anterosuperior iliac spines and if low transverse fascial incisions are not extended beyond the lateral borders of the rectus muscles.
- The lateral cutaneous nerve of the thigh and femoral nerves are associated with the anterior surface of iliacus muscle and inferolateral surface of the psoas muscles, respectively. They enter the thigh compartment by passing under the inguinal ligament. They can be compressed by the lateral blades of abdominal retractors that rest on or lateral to the psoas muscles and by excessive thigh flexion, abduction, or lateral rotation in the lithotomy position.
- Support of the pelvic organs comes from the combined action of the levator ani muscles that close the genital hiatus and provide a supportive layer on which the organs can rest and by the endopelvic fascial attachments of the vagina and uterus to the pelvic sidewalls.
- The internal iliac vessels supply the pelvic organs and pelvic wall and gluteal regions. The complexity of these multiple branches varies from individual to individual, but the key feature is the multiple areas of collateral circulation that come into play immediately after internal iliac artery ligation so that blood supply to the pelvic organs has diminished pulse pressure but continues to have flow even after the ligation.

■ The blood supply to the female genital tract is an arcade that begins at the top with input from the ovarian vessels, lateral supply by the uterine vessels, and distal supply by the vaginal artery. There is an anastomotic artery that runs along the entire length of the genital tract. For this reason, ligation of any single one of these arteries does not diminish flow to the uterus itself.

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# CHAPTER 2

# PREOPERATIVE CARE OF THE GYNECOLOGIC PATIENT

Khara M. Simpson and Karen C. Wang

**Assessing Preoperative Surgical Risk**
Patient Characteristics
Risk Scores
Procedure-Specific Risk Factors
**Preoperative Testing**
Cardiac Testing
Chest X-ray
Complete Blood Count
Coagulation Testing (PT, aPTT, Platelet Count, INR)
Electrocardiogram
Electrolytes and Creatinine
Liver Function Tests
Pregnancy Test
Pulmonary Function Tests
Type and Screen or Cross
Repeating Recent Testing
**Preoperative Considerations for COVID19**

**Managing Risk Factors: Perioperative Strategies to Prevent Specific Adverse Events**

Major Adverse Cardiac Event

Infection

Venous Thromboprophylaxis

Bowel Preparation

Hemorrhage and Transfusion

Chronic Pain Patients

Management of Perioperative Anticoagulation

Management of Patients on Chronic Antiplatelet Therapy

**Management of Chronic Medications in the Perioperative Period**

Herbal and Dietary Supplements

**Enhanced Recovery after Surgery Protocols**

**Use of Telemedicine in Preoperative Care**

A decision to pursue gynecologic surgery should consider the nature of the gynecologic condition, patient preferences, and the patient's health and medical status. Preoperative counseling should include various alternative treatment options, including expectant management, medical management, and surgical management. Prior to surgery, the informed consent process should address the likely outcome of surgery, the benefits of surgery relative to the risks and hazards, as well as alternative options. The surgeon should also discuss postoperative expectations. Anticipatory guidance during preoperative visits will reduce the patient's anxiety, promote compliance in the postoperative period, and potentially shorten the hospital stay.

Once the patient and surgeon make the decision to proceed with surgery, perioperative considerations are based on the patient's medical and prior surgical history, physical examination, planned

surgical procedure, and pathology. The goals of preoperative planning are to identify potential complications that are most likely to arise in the intraoperative and postoperative periods, thereby allowing for interventions to minimize risk and enhance recovery. In some cases, the preoperative evaluation will be a collaborative effort between the surgeon, primary care provider or specialist, and anesthesiologist.

# ASSESSING PREOPERATIVE SURGICAL RISK

When assessing preoperative surgical risk, it is helpful to consider both patient characteristics and characteristics of the surgical procedure.

## Patient Characteristics

### *Age*

With increased life expectancy, the prevalence of age-associated gynecologic disorders (such as prolapse and malignancy) is growing. Age is an independent risk factor for perioperative complications and is associated with concomitant medical problems, including diabetes, chronic obstructive pulmonary disease, renal failure, cardiovascular disease, cognitive impairment, functional impairment, malnutrition, and frailty. Preoperative risk assessment for elderly women should include an assessment of the patient's functional capacity and potential postoperative risks based on the presence of disability, dementia, and/or frailty.

### *Cardiac Disease*

Risk factors for perioperative major cardiac complications include history of prior myocardial infarction, heart failure, cerebrovascular disease, insulin-dependent diabetes, and serum creatinine >2.0 mg/dL. Other important factors include the age of the patient,

dependent functional status (defined as inability to perform activities of daily living without assistance), and American Society of Anesthesiologists' class (see Chapter 3). A more diligent preoperative evaluation is appropriate for women felt to be high risk, possibly including exercise stress test and referral for cardiology evaluation.

Patients with active coronary artery disease are at significant risk of complications during the perioperative period. Women who have had a recent cardiac event should be taken to the operating room only if the gynecologic condition is emergent and if delay in treatment is likely to have significant negative consequences. After a coronary stent has been placed, elective surgery should be delayed until after the recommended duration of antiplatelet therapy.

Perioperative collaboration with a cardiologist is appropriate for patients at high risk for cardiac complications (including those with known or suspected heart failure, history of myocardial infarction, cerebrovascular disease, insulin-dependent diabetes, and renal failure). In these cases, the goals of perioperative management are to assess perioperative risk of major cardiac complications, to optimize medical comorbidities, and to identify strategies to reduce risk of major complications (including pulmonary edema, myocardial infarction, and cardiac arrest).

## *Diabetes*

Data from the National Cardiovascular Network show that diabetic women have a high risk of perioperative complications, including acute renal failure, neurological complications, stroke, and acute myocardial infarction. Diabetes is considered a "coronary artery disease equivalent." Coronary artery disease is much more common in patients with diabetes and may be "silent"; thus, preoperative evaluation of cardiovascular risk is essential in women with long-standing or insulin-dependent diabetes. The possibility of unrecognized renal and cerebrovascular disease should also be considered.

Diabetics with poor glucose control are at greater risk of surgical site infection (SSI), silent coronary heart disease, and postoperative

cardiovascular morbidity. Optimizing glucose control is therefore considered an important component of perioperative care.

# *Hypertension*

Induction of anesthesia activates the sympathetic system, which can elevate blood pressure by 90 mm Hg and increase the heart rate by 40 bpm in patients with untreated hypertension. Hypertensive patients should continue their oral antihypertensive medications up to the day of surgery. Holding ACE inhibitors and ARBs 24 hours prior to noncardiac surgery is recommended to reduce the risk of all death, stroke, or myocardial injury. Patients on diuretics should have volume status and potassium levels closely monitored, since hypokalemia can potentiate the effects of muscle relaxants used during induction of anesthesia. Hypokalemia can increase the risk of cardiac arrhythmia and paralytic ileus.

# *Obesity*

Obesity is increasingly prevalent and is associated with numerous comorbid medical conditions (including hypertension, coronary artery disease, obstructive sleep apnea, diabetes mellitus, and gynecologic malignancies). In conjunction with metabolic syndrome, obesity places the patient at higher risk of intraoperative and postoperative complications such as pneumonia, postoperative hypoxemia, unplanned reintubation, SSIs, wound complications, and venous thromboembolism (VTE). In addition, hypoventilation syndromes (including sleep apnea) are more common in obese patients. Preoperative anesthesiology consultation is recommended for obese patients with a known or suspected history of obstructive sleep apnea and for those suspected of having a difficult airway. Appropriate preoperative subspecialty consultation should be considered for obese women who are suspected of having coronary artery disease, especially in the setting of poor exercise tolerance.

Obesity is associated with an increase in SSIs, possibly related to poor nutritional status, decreased antibiotic penetration, and decreased tissue oxygenation. Surgery for obese women may be

complicated by intraoperative technical challenges, including limited visualization, need for careful positioning, and longer operating times. These factors increase the risk of SSI and also increase the risk of wound dehiscence and incisional hernias. Special considerations for preventing VTE, prophylactic antibiotic dosing, and postoperative care are made as well and discussed in subsequent sections in this chapter.

## *Obstructive Sleep Apnea*

Obstructive sleep apnea is the most common type of sleep-disordered breathing. Patients with obstructive sleep apnea are at higher risk for respiratory complications, postoperative cardiac events, and need for ICU care. The STOP-Bang questionnaire (**TABLE 2.1**) is a validated screening tool consisting of eight questions. Patients with two or fewer positive results are considered low risk, those with three to four positive results are at intermediate risk, and those with five or more positive results are at high risk. The score can be used to predict increased risk of postoperative pulmonary and cardiac complications. Women with suspected obstructive sleep apnea may benefit from preoperative referral for formal assessment and management.

### TABLE 2.1
### STOP-Bang Questionnaire: Screening Tool for Obstructive Sleep Apnea

| | | YES | NO |
|---|---|---|---|
| Snoring | Do you snore loudly (enough to be heard through closed doors, or your bed partner elbows you for snoring at night)? | | |
| Tired | Do you often feel tired, fatigued, or sleepy during the daytime (such as falling asleep during driving)? | | |
| Observed | Has anyone observed you stop breathing or choking/gasping during your sleep? | | |
| Pressure | Do you have or are you being treated for high blood pressure? | | |
| BMI | Is your body mass index (BMI) >35 kg/m$^2$? | | |
| Age | Older than 50 y of age? | | |
| Neck | For male: Is your shirt collar 17 in or larger? (measure around Adam's apple)<br>For female: Is your shirt collar 16 in or larger? | | |
| Gender | Are you male? | | |

**Each "yes" is assigned 1 point. If score is 0-2, there is a low risk of OSA; if score is 3-4, there is an intermediate risk of OSA; and if score is 5-8, there is a high risk of OSA.**

Adapted with permission from Dr. Frances Chung and University Health Network. www.stopbang.ca

Women with known obstructive sleep apnea are advised to use continuous positive airway pressure (CPAP) therapy up to the day of surgery. Preoperative echocardiogram is recommended for those with signs/symptoms of right heart dysfunction or morbid obesity. Perioperative management of women with obstructive sleep apnea should include monitoring intraoperative serum bicarbonate levels due to the risk of associated pulmonary hypertension. For those who might otherwise be managed as an outpatient, consider inpatient postoperative recovery if high doses of narcotics are needed, if patients have additional medical problems, or if patients are unwilling to use their positive airway pressure devices at home.

## *Patients on Dialysis*

Women with renal failure are at high risk to develop perioperative fluid and electrolyte imbalances, uncontrolled blood pressure, and increased bleeding complications. These women may present with coexistent coronary artery disease and myocardial dysfunction. As a result, these patients are at high risk for perioperative mortality, with increased risk of developing pneumonia, unplanned intubation, ventilator dependence, need for reoperation within 30 days of original procedure, vascular complications, and postoperative death. Risks are greatest in dialysis patients over the age of 65.

## *Smokers*

Use of tobacco results in tissue ischemia and delayed wound healing, which increases the risk of SSI. Cigarette smokers also have an increased risk of postoperative cardiac and pulmonary complications. Smoking cessation should be urged for all patients to be completed several weeks prior to surgery.

# Risk Scores

Assessing cardiac functional capacity and frailty is also important in determining perioperative risks. Several preoperative cardiac risk assessment tools exist as a means to evaluate the risk of a cardiovascular perioperative cardiac event and optimize conditions in order to reduce morbidity and mortality.

## *NSQIP Risk Calculator*

This preoperative cardiac risk calculator was developed by the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) to provide the risk of perioperative complications based on patient history, physical examination, electrocardiogram (ECG), and planned surgical procedure. The calculator is based on 21 preoperative risk factors, with algorithms designed to be used for patients planning hysterectomy and other selected gynecologic surgery. It can also help the surgeon determine whether additional cardiac testing is indicated. The online calculator can be accessed at https://riskcalculator.facs.org.

## *Functional Capacity*

Exercise capacity is an important determinant of overall perioperative risk. This can be measured in “metabolic equivalents” (METs) (**TABLE 2.2**). An MET is a unit equal to the metabolic equivalent of oxygen uptake while quietly seated.

### TABLE 2.2
### Functional Capacity Assessment

| *Functional Capacity Measurement* | |
|---|---|
| 1 MET | Can care for self, eat, dress, use toilet independently |
| 4 METs | Can walk up a flight of stairs or hill or walk on ground level at 4 mph |
| 4-10 METs | Can do heavy housework (scrubbing floors, lifting or moving heavy furniture, or climbing two flights of stairs) |
| >10 METs | Can swim; play tennis, football, or basketball; or ski |

Adapted from Fleshier LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2014;64(22):e77-e137.

If a patient can perform four METs of activity or greater without chest pain or fatigue, the risk of postoperative cardiovascular complications should be low (**FIG. 2.1**). Examples of activities equivalent to four METs include climbing up a flight of stairs, walking up a hill, or walking at ground level at 4 mph. Those with poor exercise capacity, defined as the inability to either walk four blocks or climb two flights of stairs, are twice as likely to experience serious postoperative complications.

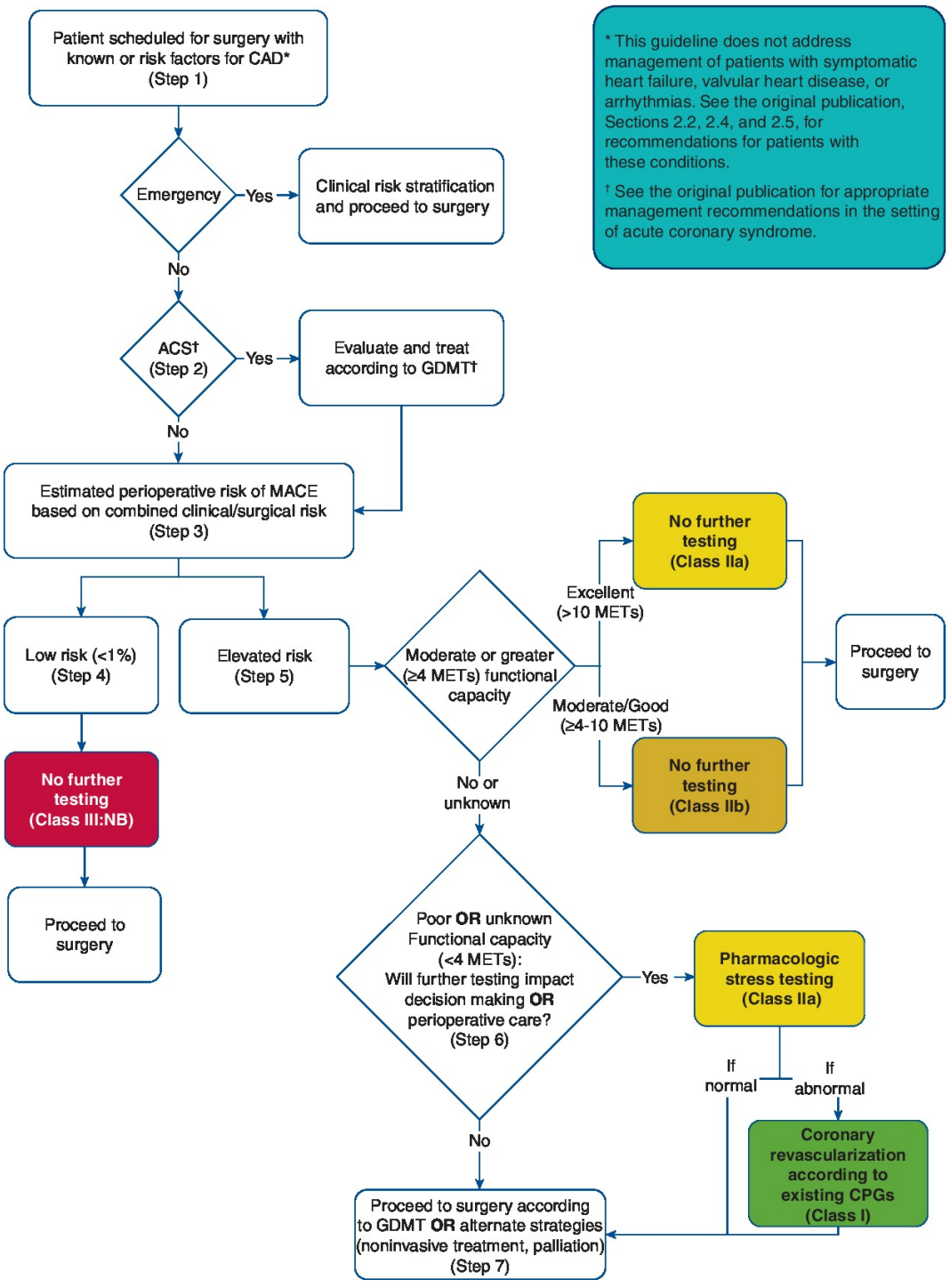


**FIGURE 2.1** Stepwise approach to perioperative cardiac assessment for coronary artery disease (CAD). CPG, clinical practice guideline; GDMT, guideline-directed medical

therapy; MACE, major adverse cardiac event; MET, metabolic equivalent; NB, no benefit. (Reprinted with permission from Fleshier LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing non cardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;130(24):2215-2245. Copyright © 2014 by the American College of Cardiology Foundation and the American Heart Association, Inc.)

## *Frailty*

Frailty is defined as a state of deteriorated physiological reserve, diminished strength, and reduced endurance to maintain homeostasis. Frailty is characterized by high vulnerability to even mild stressors and health impairment, including functional dependence, worsening disability, hospitalizations, and high mortality. In comparison to nonfrail patients, frail patients are seven times more likely to suffer disability within 1 month of surgery. A study by Courtney-Brooks et al. showed that the 30-day surgical complication rate after a major staging procedure for gynecologic malignancy was 24% among nonfrail women but increased to 67% among frail women. Postoperative complications related to frailty include sepsis, urinary tract infection (UTI), respiratory (pneumonia or pulmonary embolism), neurological (stroke, coma, cerebral accident), renal, and cardiac (myocardial infarction, heart failure, and arrhythmia). Frailty also leads to prolonged recovery and potential

need for rehabilitation. Frailty should be suspected among women with at least three of the following: muscle weakness, poor endurance, low physical activity, slow gait speed, and significant weight loss. In this setting, consider referral to an internist or geriatrician for formal evaluation. Frail patients are encouraged to initiate strength training and conditioning and take nutritional supplements to improve postoperative recovery and survival.

## Procedure-Specific Risk Factors

Surgical characteristics that impact perioperative risk include surgical approach (vaginal, abdominal, laparoscopic, or robot assisted), type of surgery (eg, myomectomy vs hysterectomy), and characteristics associated with the gynecologic disease (eg, complexity of disease, extent of pathology, malignancy). Patients with a history of several abdominopelvic surgeries and those with malignancy or advanced endometriosis are at greater risk of adhesive disease, distorted anatomy, and blood loss. Similarly, patients with extensive pelvic pathology (such as large fibroids or adnexal masses) can have significantly distorted anatomy, increasing the risk of bleeding or inadvertent injury to adjacent organs. In such cases, appropriate planning allows the surgeon to secure adequate surgical assistance and personnel, as well as to select appropriate prophylactic antibiotics and possible blood products.

# PREOPERATIVE TESTING

The goal of preoperative testing is to identify opportunities to minimize perioperative risk. Selective preoperative testing before gynecologic surgery should be based on patient's clinical history, comorbidities, physical examination findings, and potential risks of the planned surgical procedure. Unfortunately, insufficient scrutiny of the value of diagnostic testing in the past has led to excessive or unnecessary preoperative testing. In recent decades, research has shown that "routine" preoperative laboratory testing in a healthy population undergoing elective surgery does not change clinical management, affect mortality, or reduce the frequency of adverse

events. Preoperative tests should be selected according to the clinical situation, with objectives to stratify risk, direct anesthetic choices, and guide postoperative management. Some preoperative test recommendations are based on disease (TABLE 2.3).

## TABLE 2.3
## Summary of Preoperative Testing Recommended for Selected Clinical Settings

| CONDITION(S) | RECOMMENDED PREOPERATIVE TESTING |
|---|---|
| Cardiac disease (eg, coronary artery disease, valvular heart disease, prior MI, heart failure, cerebrovascular disease) | • May include baseline ECG and stress testing, echocardiogram, 24-h ambulatory monitoring<br>• Consider CXR if valvular heart disease or congestive heart disease |
| Diabetes mellitus | • Baseline ECG<br>• Consider serum electrolytes and creatinine<br>• HbA1c within the last 4-6 wk<br>• Additional noninvasive cardiac testing if indicated |
| Hypertension | • Serum electrolytes and creatinine<br>• Consider baseline ECG |
| Obesity | • Screen for obstructive sleep apnea (STOP-Bang questionnaire)<br>• Consider assessment for diabetes, cardiac disease<br>• Consider preoperative anesthesia consultation |
| Obstructive sleep apnea | • Consider echocardiogram<br>• Serum electrolytes |
| Dialysis | • Consider cardiac evaluation<br>• Serum electrolytes (including Ca, $PO_4$, Mg) and creatinine<br>• Albumin<br>• CBC<br>• Coagulation profile<br>• Urinalysis |
| Pulmonary disease (asthma, COPD) | • Pulmonary function tests (if unexplained dyspnea or poorly controlled chronic respiratory disease)<br>• CXR (if active pulmonary disease) |
| Liver disease | • CBC<br>• Coagulation testing<br>• Liver function tests |

# Cardiac Testing

In high-risk patients, such as those with known or suspected coronary artery or valvular heart disease, the risk of perioperative of death is >1%. In this setting, cardiology consultation should be considered. Additional testing (including stress testing, echocardiogram, or 24 hours ambulatory monitoring) might be indicated.

# Chest X-ray

For patients undergoing gynecologic surgery, routine preoperative chest radiographs are not indicated unless there is known or suspected cardiopulmonary disease.

# Complete Blood Count

Baseline hemoglobin and hematocrit is important in scenarios where baseline anemia is likely (chronic renal disease, hepatic disease, malignancy, heavy vaginal bleeding) and prior to procedures where significant bleeding is anticipated (presence of adhesive disease, endometriosis, large fibroid uteri). Preoperative anemia should alert the surgeon to the potential need for blood transfusion as well as provide an opportunity to correct anemia, when possible, to optimize perioperative outcomes and recovery. A complete blood count will rarely identify unsuspected white blood cell or platelet abnormality. A preoperative platelet count is helpful when neuraxial anesthesia is planned.

# Coagulation Testing (PT, aPTT, Platelet Count, INR)

Routine preoperative tests of hemostasis are not recommended unless there is suspicion or presence of a bleeding disorder or when managing chronic anticoagulation and bridging therapy.

# Electrocardiogram

A preoperative ECG is not needed for low-risk procedures. Preoperative ECG is recommended for patients with known coronary artery disease, significant arrhythmia, peripheral arterial disease, cerebrovascular disease, or other significant structured heart disease who will be undergoing surgery with elevated risk. A baseline ECG may be valuable for women over the age of 50 planning a major gynecologic procedure.

# Electrolytes and Creatinine

Routine screening for electrolyte abnormalities is not recommended unless the patient has a history that suggests the likelihood of an abnormality such as chronic renal disease and use of medications that affect electrolytes (such as diuretics, ACE inhibitors, or ARBs). Evaluation of serum creatinine concentration is recommended for patients with underlying renal disease, if hypotension is likely during surgery, or when nephrotoxic medications are expected to be used.

# Liver Function Tests

Routine liver enzyme testing is not recommended in preparation for surgery unless chronic liver disease is suspected or present.

# Pregnancy Test

For all reproductive-aged women with a uterus and without permanent sterilization, pregnancy should be excluded. This is especially important for women not on reliable contraception. Urine qualitative HCG, ideally on the day of surgery, should be sufficient to exclude pregnancy.

# Pulmonary Function Tests

Pulmonary function tests are only recommended in patients with unexplained dyspnea and for those with poorly controlled chronic respiratory disease.

# Type and Screen or Cross

A type and screen is used to evaluate for the presence of antibodies, which can limit the availability of blood products in case a blood transfusion is needed. If the patient is anemic before surgery or actively bleeding or the planned procedure is at risk of significant bleeding, a type and cross is essential as part of the preoperative testing.

## Repeating Recent Testing

Unless there has been a change in the patient's clinical status, it is reasonable to rely on test results that were normal and performed within the past 4 months. Preoperative test results that were abnormal should be repeated.

# PREOPERATIVE CONSIDERATIONS FOR COVID-19

In 2020, early studies from Wuhan, China showed that asymptomatic patients with SARS-Cov2 were at high risk of perioperative morbidity (44.1% ICU admission rate) and 20.7% mortality rate when undergoing elective surgery. During the global COVID-19 pandemic, institutions implemented testing preoperatively to minimize potential perioperative morbidity and mortality as well as to minimize the risk of transmission to medical staff and other patients. COVID testing is typically performed between 1 and 3 days prior to surgery. Some centers have recommended self-quarantine after testing to avoid exposure and infection prior to surgery to avoid perioperative complications or surgical delay.

While perioperative morbidity is increased during COVID-19 infection, it is unclear how long after infection it is safe to proceed with elective surgery. One study showed a significantly higher risk of pulmonary complications and death within the first 4 weeks of diagnosis. A separate international prospective cohort study found that patients who had surgery within 6 weeks of SARS-CoV-2 diagnosis had an increased risk of 30-day postoperative mortality and 30-day postoperative pulmonary complications. In a joint statement from the American Society of Anesthesiologists and Anesthesia Patient Safety Foundation regarding elective surgery and anesthesia after COVID-19 infection that was released on March 9, 2021, suggested wait times for surgery are 4 weeks for an asymptomatic patient or recovery from mild nonrespiratory symptoms; 6 weeks for symptomatic patient who did not require hospitalization; 8-10 weeks for symptomatic patient who is diabetic,

is immunocompromised, or was hospitalized; and 12 weeks for a patient who was admitted to the ICU for COVID-19. The CDC discourages repeat COVID PCR testing within 90 days of symptom onset unless there is a recurrence of symptoms.

# MANAGING RISK FACTORS: PERIOPERATIVE STRATEGIES TO PREVENT SPECIFIC ADVERSE EVENTS

## Major Adverse Cardiac Event

Most women are at low risk for cardiac events associated with gynecologic surgery. Preoperative evaluation of symptoms (angina, dyspnea, syncope, palpitations) and medical history (heart disease, hypertension, diabetes, chronic renal disease, and cerebrovascular or peripheral artery disease) in conjunction with determination of functional status (METs) will indicate if additional testing is needed (ECG, stress testing, cardiology consultation). For patients with coronary and vascular stents, preoperative consultation with their cardiologist is imperative (see **FIGURE 2.1**). In the past, beta-blockers were thought to decrease perioperative morbidity and cardiovascular complications for patients with arterial disease; however, data from the POISE trial showed an increased risk of morbidity and stroke. As a result, perioperative beta-blocker use is recommended for patients on long-term therapy for hypertension, atrial fibrillation, angina, heart failure, or prior myocardial infarction. It may be reasonable to administer beta-blockers for patients with multiple risk factors (eg, diabetes, heart failure, coronary artery disease, renal insufficiency, cerebrovascular accident). Such patients are typically managed collaboratively with a medical consultant. Perioperative prophylactic beta-blocker therapy should begin 7-30 days before surgery.

# Infection

## *Surgical Site Infection*

By definition, surgical site infection (SSI) is an infection related to surgery occurring at or near surgical incision and within 30 days of surgery (or 12 months if an implant was placed). Most gynecologic SSIs consist of superficial incisional infections of the skin and subcutaneous tissue. Factors that affect SSI include bacterial virulence, bacteria type, and bacterial load. Infection risk is also influenced by patient characteristics such as resistance, presence of foreign body, obesity, tobacco use, diabetic control, operating time, and temperature. The reported rate of SSI rate after gynecologic surgery, 2%-5%, is likely an underestimate since many infections related to surgery occur after discharge from the hospital (and patients may seek care elsewhere). It has been estimated that each SSI related to hysterectomy adds $5000 in patient costs.

In response, the Joint Commission on the Accreditation of Healthcare Organizations has made recommendations on reducing SSI. Recommendations include the timing and selection of prophylactic antibiotics, the importance of glucose control, and appropriate hair removal technique.

### Prophylactic Antibiotics

Broad spectrum prophylactic antibiotics are recommended in selected surgeries. Antibiotic selection should consider coverage of vaginal and skin flora, including Gram-positive, Gram-negative, and anaerobic organisms. Antibiotic prophylaxis is best administered within 60 minutes prior to the start of surgery to insure adequate circulating and tissue levels of the antibiotic prior to bacterial inoculation (eg, with skin incision). For gynecologic surgery, cephalosporins are an excellent choice for prophylaxis, due to their broad coverage and low incidence of allergic reaction or side effects. Cefazolin 1 or 2 g IV is recommended, with additional doses provided when the surgery exceeds 4 hours or if the blood loss is >1500 mL. For obese patients weighing more than 120 kg, 3 g cefazolin is advised. More detailed recommendations are

summarized in **TABLE 2.4**. Though it is not currently recommended as standard of care, emerging evidence suggests that metronidazole in addition to cefazolin may further reduce the risk of SSI specifically at the time of hysterectomy. A retrospective cohort study based on the Michigan Surgical Quality Collaborative consisting of 18 255 patients undergoing hysterectomy for both benign and malignant disease suggested that the addition of metronidazole to cefazolin would lead to an absolute risk reduction of 0.8% in posthysterectomy SSI rates. When controlling for patient risk factors (body mass index [BMI], hypertension, diabetes mellitus, smoking); treatment factors (surgical time, surgical route, estimated blood loss, bowel surgery, lymph node dissection); and disease state (malignancy), the risk of SSI was significantly higher if only cefazolin was used (odds ratio 2.30) compared to cefazolin and metronidazole.

## TABLE 2.4
## Antimicrobial Prophylactic Regimens by Procedure

| PROCEDURE | ANTIBIOTIC | DOSE (SINGLE DOSE WITHIN 1 HOUR BEFORE PROCEDURE)[a,b] |
|---|---|---|
| Hysterectomy (including supracervical)[c]<br>Vaginal<br>Abdominal<br>Laparoscopic<br>Robotic | Cefazolin | 2 g, 3 g IV for patients weighing >120 kg[d] |
| Uterine evacuation<br>Suction D&C<br>D&E | Doxycycline | 200 mg |
| Colporrhaphy | Cefazolin | 2 g, 3 g IV for patients weighing >120 kg[d] |
| Vaginal sling placement | Cefazolin | 2 g, 3 g IV for patients weighing >120 kg[d] |
| Laparotomy without entry into bowel or vagina | Consider cefazolin | 2 g, 3 g IV for patients weighing >120 kg[d] |
| Cervical tissue excision procedures (ILEEP, biopsy, endocervical curettage) | Not recommended | |
| Cystoscopy | Not recommended | |
| Endometrial biopsy | Not recommended | |
| Laparoscopic procedures without entry into bowel or vagina | Not recommended | |
| Hysterosalpingogram<br>Chromotubation<br>Saline infusion sonography | Not recommended | |
| Intrauterine device insertion | Not recommended | |
| Oocyte retrieval | Not recommended | |
| D&C for nonpregnancy indications | Not recommended | |
| Urodynamics | Not recommended | |

[a]In surgical cases with blood loss >1500 mL, a second dose of the prophylactic antibiotic may be appropriate (Anderson DJ, Podgomy K, Berrios-Torres SI, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35[suppl 2]:S66-88; Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Hearth Syst Pharm. 2013;70:195-283; Swoboda SM, Merz C, Kostuik J, Trentler B, Lipsett PA. Does intraoperative blood loss affect antibiotic serum and tissue concentrations? Arch Surg. 1996;131:1165-1171; discussion 1171-2).

[b]For lengthy procedures, additional intraoperative doses of an antibiotic, given at intervals of two times the half-life of the drug measured from the initiation of the preoperative dose, not from the onset of surgery (for cefazolin, this is 4 h), maintain adequate levels throughout the operation (Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Society of Health-System Pharmacists, Infectious Diseases

Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm. 2013;70:195-283).

[c]Screening for bacterial vaginosis in women undergoing hysterectomy can be considered.

[d]Joint guidelines from the American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, and the Society for Healthcare Epidemiology of America recommend cefazolin 2 g as the standard prophylactic dose, with 3 g for patients who weigh more than 120 kg (Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Society of Health-System Pharmacists, Infectious Diseases Society of America. Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm. 2013;70:195-283). The rationale for the 2-g dose in all patients who weigh 120 kg or less is to simplify the dosage. Older studies and previous ACOG guidelines recommended a l-g dose, which still can be considered for patients who weigh 80 kg or less.

Abbreviations: D&C, dilation and curettage; D&E, dilation and evacuation; LEEP, loop electrosurgical excision procedure.Reprinted with permission from Prevention of infection after gynecologic procedures. ACOG Practice Bulletin No. 195. American College of Obstetricians and Gynecologists. *Obstet Gynecol*. 2018;131(6):e172–e189.

## Urogynecologic Procedures

While no prospective studies have been performed, prophylactic antibiotics are advised for urogynecology procedures, including those involving mesh. In cases where patients are discharged home with an indwelling urinary catheter, daily antibiotic prophylaxis may also be considered.

## Glycemic Control

Diabetic patients with hyperglycemia are at increased risk for SSIs. The American Diabetes Association endorses a target glucose range of 80-180 mg/dL for the perioperative period. When possible, working to achieve a hemoglobin A1c of <7% is optimal prior to surgery to minimize postoperative complications. American College of Obstetricians and Gynecologists (ACOG) recommends blood glucose target levels of <200 mg/dL. For procedures lasting <2 hours, subcutaneous insulin can be used perioperatively to manage intraoperative glucose levels.

## Surgical Site Preparation and Hair Removal

SSI prevention includes proper abdominal skin and vaginal preparation for gynecologic surgery. The Centers for Disease Control and Prevention (CDC) advises that patients bathe the night before surgery with either soap or antiseptic agent. Some practices will provide patients with chlorhexidine gluconate solution for this purpose. The combination of 4% chlorhexidine gluconate showers before surgery, perioperative prophylactic antibiotic administration, and preoperative skin preparation (with 2% chlorhexidine gluconate and 70% isopropyl alcohol) was found to reduce the risk of SSI by 82.4% after major gynecologic cancer surgery.

In the operating room, the abdominal wall should be prepped with 4% chlorhexidine gluconate solution with 70% isopropyl alcohol. A large randomized controlled trial showed that chlorhexidine-alcohol was significantly more effective than a povidone-iodine scrub in preventing incisional infections. The vagina should be prepped with either povidone-iodine or chlorhexidine gluconate with 4% isopropyl alcohol. If the patient is allergic to iodine and chlorhexidine cannot be used, sterile saline or baby shampoo can be used to prep the vagina.

Based on a 2011 Cochrane review, hair removal is typically not advised unless the hair is within or around the incision site. If hair removal is necessary, clippers should be used immediately before surgery. Alternatively, depilatory agents can be used preoperatively. Both strategies are preferred over shaving with razors.

# *Bacterial Vaginosis*

Bacterial vaginosis is a risk factor for posthysterectomy SSI. Symptomatic patients should be assessed for bacterial vaginosis and treated before surgery. Patients with bacterial vaginosis should be treated for at least 4 days prior to hysterectomy to reduce the risk vaginal cuff cellulitis. Screening of asymptomatic patients is not indicated.

# *Chlamydia and Gonorrhea*

Infection with *Chlamydia trachomatis* or *Neisseria gonorrhea* increases the risk of endometritis after the surgical termination of a pregnancy. Among women planning pregnancy termination, treatment should be provided for those with positive testing. Also, empiric treatment may be advised for patients at risk.

## *Infective Endocarditis*

A revision of the American Heart Association guideline for the prevention of infective endocarditis in 2007 has led to the discontinuation of routine prophylactic antibiotics to prevent endocarditis for gynecologic procedures.

# Venous Thromboprophylaxis

Adhering to the law of Virchow triad, the three factors that contribute to risk of thrombosis are hypercoagulability, stasis, and endothelial injury or tissue trauma. Gynecologic surgery fulfills all three criteria. The highest risk of VTE is associated with complicated surgeries that require prolonged anesthesia or lengthy convalescence or involve malignancy. Gynecologic surgeons must consider patient characteristics, medical history, and the nature of the planned surgery to determine which type of perioperative prophylaxis is indicated.

The American College of Chest Physicians (ACCP) provides guidelines for perioperative thromboprophylaxis based on risk categories (Caprini risk assessment score). The recommendations for gynecologic patients are extrapolated from general surgery, urology, and colorectal surgery. The Caprini score (**TABLE 2.5**), based on a variety of different risk factors, determines VTE risk category (eg, very low, low, moderate, or high risk). Recommendations for perioperative thromboprophylaxis are based on these four risk categories but may be modified based on the risk of perioperative hemorrhage (**TABLE 2.6**). Most gynecologic surgery patients will fall into the moderate-risk category; patients with gynecologic cancer are in a higher-risk group. For the moderate-risk category, options for VTE prevention include the use of sequential

compression stockings, pharmacologic agents, or both. Current ACOG guidelines for VTE prophylaxis support ACCP guidelines and use of the Caprini score.

## TABLE 2.5
## Caprini Risk Assessment Model

| 1 POINT | 2 POINTS | 3 POINTS | 5 POINTS |
|---|---|---|---|
| • Age 41-60 y<br>• Minor surgery<br>• BMI > 25 kg/m²<br>• Swollen legs<br>• Varicose veins<br>• Pregnancy or postpartum<br>• History of unexplained or recurrent spontaneous abortion<br>• Oral contraceptives or hormone replacement<br>• Sepsis (<1 mo)<br>• Serious lung disease including pneumonia (<1 mo)<br>• Abnormal pulmonary function<br>• Acute myocardial infarction<br>• Congestive heart failure (<1 mo)<br>• History of inflammatory bowel disease<br>• Medical patient at bed rest | • Age 61-74 y<br>• Arthroscopic surgery<br>• Major open surgery (>45 min)<br>• Laparoscopic surgery (>45 min)<br>• Malignancy<br>• Confined to bed (>72 h)<br>• Immobilizing plaster cast<br>• Central venous access | • Age ≥75 y<br>• History of VTE<br>• Family history of VTE<br>• Factor V Leiden<br>• Prothrombin G20210A<br>• Lupus anticoagulant<br>• Anticardiolipin antibodies<br>• Elevated serum homocysteine<br>• Heparin-induced thrombocytopenia<br>• Other congenital or acquired thrombophilia | • Stroke (<1 mo)<br>• Elective arthroplasty<br>• Hip, pelvis, or leg fracture<br>• Acute spinal cord injury (<1 mo) |

Reprinted from Gould MK, Garcia DA, Wren SM, et al. Prevention of VTE in nonorthopedic surgical patients: antithrombotic therapy and prevention of thrombosis. 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2):e227S-e277S. Copyright © 2012 The American College of Chest Physicians, with permission.

## TABLE 2.6
## Recommendations for VTE Prevention, Based on Caprini Risk Score

| CATEGORY | CAPRINI SCORE | ESTIMATED VTE RISK | RECOMMENDATIONS |
|---|---|---|---|
| **Very low risk** | 0 | <0.5% | Early and frequent ambulation |
| **Low risk** | 1-2 | 1.5% | Mechanical prophylaxis, preferably with intermittent pneumatic compression |
| **Moderate risk** | 3-4 | 3% | If low risk for major bleeding: use LMWH, LDUH, or mechanical prophylaxis (preferably with intermittent pneumatic compression)<br>If high risk for major bleeding: mechanical prophylaxis (preferably with intermittent pneumatic compression) |
| **High risk** | ≥5 | 6% | Combined pharmacologic and mechanical methods; consider extended-duration pharmacologic prophylaxis (4 wk) |

LDUF, low-dose unfractionated heparin; LMWH, low molecular weight heparin.

Adapted from Gould MK, Garcia DA, Wren SM, et al. Prevention of VTE in nonorthopedic surgical patients: antithrombotic therapy and prevention of thrombosis. 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2):e227S-e277S. Copyright © 2012 The American College of Chest Physicians, with permission.

Using data from gynecologic surgery, the Society of Gynecologic Surgeons Systematic Review Group developed a clinical practice guideline for VTE prophylaxis (**TABLE 2.7**). Compared to the guidelines of the ACCP, the Society of Gynecologic Surgeons recommendations are based on a more simplified risk scoring system, emphasizing the presence of malignancy and gynecologic surgery type.

## TABLE 2.7
## Society of Gynecologic Surgeons Systematic Review Group Summary of Clinical Guidelines for Prevention of Venous Thromboembolism (VTE) in Gynecologic Surgery

| GYNECOLOGIC SURGERY TYPE | GYNECOLOGIC MALIGNANCY | PRIOR VTE | OTHER RISK FACTORS FOR VTE | AGE | WE SUGGEST THE FOLLOWING: | GRADE |
|---|---|---|---|---|---|---|
| Minor | No | No | No | Any | Early and frequent mobilization with or without perioperative intermittent pneumatic compression | 2C |
| Major | No | No | No | Any | Use intermittent pneumatic compression before anesthesia induction and continue until discharge | 2C |
| Any | No | Yes | Yes or no | ≥60 year old | Use intermittent pneumatic compression before anesthesia induction and continue until discharge and either LMWH or UFH | 2C |
| Any | Yes or suspected | No history of VTE, no risk VTE risk factors, and age <60 y | | | Use intermittent pneumatic compression before anesthesia induction and continue until discharge and perioperative LMWH or UFH | 2C |
| Any | Yes or suspected | Either history of VTE or age of 60 y or older | | | Use intermittent pneumatic compression before anesthesia induction and continue until discharge and perioperative LMWH or UFH and continuation of postoperative therapy for 2-4 wk after discharge | 2C |

LDUF, low-dose unfractionated heparin; LMWH, low molecular weight heparin.
Reprinted with permission from Rahn DD, Mamik MM, Sanses TV, et al. Venous thromboembolism prophylaxis in gynecologic surgery: a systematic review. *Obstet*

*Gynecol*. 2011;118(5):1111-1125. Copyright © 2011 by The American College of Obstetricians and Gynecologists.

# Bowel Preparation

Recent studies have demonstrated that mechanical bowel preparation has limited value in gynecologic surgery. In cases where small bowel and large bowel injuries are anticipated (eg, significant adhesive disease from prior surgery or inflammatory process), enteral antibiotics can be considered to reduce infection. However, there is no evidence to show that mechanical bowel preparation with or without prophylactic antibiotics reduces the risk of infection or injury.

# Hemorrhage and Transfusion

Severe postoperative anemia affects morbidity and mortality, with a pronounced increase in mortality when hemoglobin levels fell below 7 g/dL. If the primary complaint involves heavy and abnormal bleeding, evaluation for a bleeding disorder may be indicated. For nonurgent surgery in the setting of anemia, the surgeon should endeavor to correct the baseline anemia preoperatively with such interventions including the use of iron supplementation (PO or IV), medical treatment of abnormal bleeding (GnRH agonists, combination oral contraceptives, progestin only, tranexamic acid), or use of erythropoiesis stimulating agents (recombinant human erythropoietin and darbepoetin alfa). The FDA issued a warning about recombinant human erythropoietin use in cancer patients due to the risk of serious cardiac and thrombovascular events and tumor progression. Small case series suggest that the use of arterial embolization with resorbable gelatin sponge prior to myomectomy or hysterectomy may be a useful adjunct to minimize bleeding at the time of surgery for large fibroids.

For surgeries likely to result in significant anemia, the use of autologous blood (cell salvage) intraoperatively may be considered. Cell salvage is the process of collecting the blood that is lost during the surgery, filtering and processing it, and returning it to the patient.

This intervention is an alternative to preoperative autologous blood donation or homologous blood transfusion and has the potential to eliminate the risk of transfusion reaction. Access depends on the institution. Cell salvage is the preferred option for patients who are Jehovah's Witnesses.

Intraoperative medications including vasopressin, misoprostol, and tranexamic acid have been shown to decrease blood loss at the time of myomectomy and can be used as adjuncts to minimize blood loss as long as there are no contraindications. Tourniquets and use of temporary vascular clamps can also be utilized during a myomectomy to reduce intraoperative blood loss.

## Chronic Pain Patients

Due to the narcotic tolerance associated with chronic opioid use, patients with this history should be educated about the need for a multimodal approach to postoperative pain management. Reassurance and setting reasonable expectations for pain control postoperatively are essential to manage these patients. To improve analgesia, the combined use of nonopioid analgesic agents (aspirin, acetaminophen, nonsteroidal anti-inflammatory drugs, COX 2 inhibitors), tramadol, opioids, antidepressants, antiepileptic drugs, muscle relaxants, NMDA receptor antagonists, and topical or local anesthetics is recommended when possible. Screening for comorbidities such as depression and anxiety is important to optimize treatment. Use of neuraxial anesthesia (epidural) and regional anesthesia intraoperatively (such as the local injection of anesthesia, transversus abdominis plane (TAP) block) is useful especially in patients who undergo major abdominal surgery.

## Management of Perioperative Anticoagulation

For patients receiving anticoagulant therapies, the surgeon must consider the risks associated with continuing versus stopping therapy for surgery. In some cases, it is appropriate to transition the patient to a short-acting or easily reversible "bridging therapy"

(**TABLE 2.8**). Examples of bridging therapy include low molecular weight heparin (LMWH) and unfractionated heparin (UFH).

## TABLE 2.8
## Options for Anticoagulation "Bridging"

| |
|---|
| Therapeutic dose: (goal is maintaining aPTT 1.5-2 times control aPTT) |
| Enoxaparin 1 mg/kg bid or<br>Dalteparin 100 IU/kg bid or 200 IU/kg daily or<br>Tinzaparin 175 IU/kg daily or<br>IV unfractionated heparin |
| Prophylactic dose: |
| Enoxaparin 30 mg bid or 40 mg daily or<br>Dalteparin 5000 IU daily or<br>Unfractionated heparin 5000-7500 IU sc bid |

Data from Douketis JD, Spyropoulos AC, Spencer FA, et al. Perioperative management of antithrombotic therapy. Antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141 (2 suppl):e326S-e350S.

For patients taking a vitamin K antagonist, such as warfarin, recommendations are to stop medication 5 days prior to surgery, with a transition to bridging therapy for that interval. To ensure that the anticoagulant effect has resolved, the surgical team should check INR the day prior to surgery and if not normalized, the surgeon can give 1-2 mg oral vitamin K and repeat INR on the day of the procedure. Typically, the patient can resume taking a vitamin K antagonist 12-24 hours after surgery.

For the bridging therapy, the surgeon should give the last dose of LMWH 24 hours before surgery and intravenous UFH until 4-6 hours before surgery. Continue bridging therapy postoperatively until INR reaches therapeutic levels, which usually takes 5 days. Patients who are on chronic LMWH can restart therapeutic subcutaneous LMWH

48-72 hours after completion of surgery. Less is known about the perioperative use of newer oral anticoagulant therapies (direct factor Xa inhibitors rivaroxaban and apixaban and direct thrombin inhibitor dabigatran). Without an existing reversal agent, the management of these medications for emergent or urgent surgery is difficult. Two current schemes have been proposed: stopping the medication 5 days prior to surgery and initiating bridging therapy or stopping it 1-5 days prior to surgery without bridging therapy. The perioperative management of these medications should be a collaboration with the patient's cardiologist, PCP, or hematologist.

## Management of Patients on Chronic Antiplatelet Therapy

Risks associated with the interruption of chronic antithrombotic therapy are different from the risk of postoperative VTE. Antiplatelet (antithrombotic) therapies are intended to prevent arterial thromboembolism.

The 2012 ACCP guidelines provide recommendations for patients on chronic antithrombotic therapy. These guidelines include indications for bridging therapy, therapeutic options, and when to resume chronic anticoagulation postoperatively (based on the individual risk of thromboembolism and risk of major bleeding associated with the planned surgery). The risk of bleeding associated with surgery must be considered and weighed against the risk of thromboembolic complications, with a goal to minimize uncontrolled bleeding at the time of surgery while avoiding a thromboembolic event.

For patients with a mechanical heart valve or atrial fibrillation, bridging therapy is recommended. Patients receiving aspirin as antiplatelet therapy should not discontinue this treatment in the perioperative period.

# MANAGEMENT OF CHRONIC MEDICATIONS IN THE

# PERIOPERATIVE PERIOD

Most medications can be continued in the perioperative period. However, there is a paucity of data regarding the optimal perioperative management of chronic medications. Selected best practices are summarized here.

- *Beta-blockers:* Among women who use beta-blockers chronically (eg, to control angina or arrhythmias), it is essential to continue these medications in the perioperative period. In addition, among women at highest risk of perioperative cardiac events, the use of preoperative beta-blockers, initiated at least 7-30 days before surgery, is associated with a reduction in cardiac events. Beta-blockers are thought to reduce ischemia by decreasing myocardial oxygen demand due to increased catecholamine release and by preventing or controlling arrhythmias.
- *ACE Inhibitors, Angiotensin II receptor blockers*: There is concern about perioperative use due to prolonged hypotension, but these medications can also possibly reduce postoperative hypertension. These medications should be held for 24 hours prior to surgery but can be safe to continue in the perioperative period in patients with congestive heart failure or poorly controlled hypertension. Administration of angiotensin II receptor blockers should resume within 48 hours after surgery to minimize 30-day mortality.
- *Alpha 2 agonists*: Continue in the perioperative period due to risk of withdrawal and rebound hypertension.
- *Asthma medications*: No need to discontinue these medications for surgery.
- *Calcium channel blockers*: No need to discontinue these medications for surgery.
- *Clopidogrel:* Recommend stopping the medication 5-7 days prior to surgery and restarting 12-15 hours after surgery. Begin with loading dose and then resume therapeutic dose 12-24 hours after surgery.

- *Corticosteroids*: Preoperative stress dose steroids are indicated for two groups of women. First, patients on chronic steroids (>3 weeks) are at risk of perioperative adrenal insufficiency if therapy is interrupted. Therefore, in this setting glucocorticoids should be continued perioperatively in combination with stress dosing at the time of surgery (**TABLE 2.9**). Also, women who are not taking steroids at the time of surgery but who have received a course of high-dose steroids (defined as >20 mg prednisone or equivalent for 5 or more days) within 2 months of surgery should be considered potentially adrenally insufficient. Such patients should also receive stress dose steroids (**TABLE 2.9**). Stress dose steroids are not indicated for patients taking any dose of glucocorticoid for <3 weeks and for those receiving <5 mg/d of prednisone or an equivalent.
- *Digoxin*: No need to discontinue the medication for surgery.
- *Diuretics*: Hold diuretics on the morning of surgery due to concern of hypokalemia (which can theoretically increase risk of perioperative arrhythmia and may potentiate effects of muscle relaxants or provoke paralytic ileus) and hypovolemia. This therapy can be resumed when the patient is taking oral fluids. The surgeon may consider perioperative parenteral use of a diuretic if the patient is taking it for heart failure.
- *H2 blockers, Proton pump inhibitors*: No need to discontinue these medications for surgery.
- *Hypolipidemic nonstatin drugs (niacin, gemfibrozil, and fenofibrate):* Recommend discontinuing the day before surgery. This class of medications can cause myopathy and rhabdomyolysis, which can be a higher risk in the perioperative period. Cholestyramine and colestipol can also interfere with bowel absorption of medications. Perioperative risks of ezetimibe are unknown.
- *Insulin*: If a patient is receiving once-a-day dosing or if she has an insulin pump, she can continue her usual dose. Ideally, insulin-dependent diabetics are accommodated for surgery the first thing in the morning. For surgeries later in the day, insulin levels should be reduced on the day of surgery. Dosing should be reduced by one-half to two-thirds if the patient is using daily

dosing and by one-third to one-half if insulin is administered two or more times a day. Careful perioperative monitoring of serum glucose is mandatory.

- *Nonsteroidal antiinflammatory drugs (NSAIDs)*: When possible, we advise discontinuing NSAIDs 3 days prior to surgery (except where patients require the medication for adequate pain control). Ibuprofen affects platelet function for only 24 hours, so it can be stopped 24 hours prior to surgery.
- *Oral contraceptives or Hormone Replacement Therapy:* For low-risk procedures (and if early ambulation is anticipated), estrogen-based hormones can be continued in the perioperative period. For elective moderate or high-risk procedures, some recommend stopping the medication 4-6 weeks before surgery to avoid thromboembolic events. If there is insufficient time to stop the medication for a high-risk procedure (<4-6 weeks), thromboprophylaxis would be indicated. The increased risk of VTE should be balanced against possible sequelae of stopping these medications, including unintended pregnancy, heavy or prolonged bleeding resulting in anemia, and climacteric symptoms (hot flushes).
- *Oral hypoglycemic agents*: All oral hypoglycemic drugs (sulfonylureas, metformin, thiazolidinediones, sodium-glucose cotransporter 2 inhibitors, and dipeptidyl peptidase IV) should be continued until the morning of surgery and held that morning. Sulfonylureas can increase the risk of hypoglycemia. Metformin is contraindicated in conditions where tissue hypoxia, lactate accumulation, or renal hypoperfusion can occur. While most oral hypoglycemic agents can be restarted after surgery once the patient is eating, metformin should be delayed in patients with suspected renal hypoperfusion, significant hepatic impairment, or congestive heart failure. Metformin can be resumed upon establishment of adequate renal function.
- *Statins*: No need to discontinue these medications for surgery.

## TABLE 2.9
## Recommendations for Stress Dose Steroids in

## Surgery

| COMPLEXITY OF SURGERY | RECOMMENDATIONS |
|---|---|
| Minor procedure or local anesthesia (ie, inguinal hernia repair) | Take usual morning steroid dose. |
| Moderate surgical stress (ie, lower extremity revascularization, total joint replacement) | Take usual morning steroid dose + 50 mg hydrocortisone IV just before procedure + 25 mg hydrocortisone every 8 h for 24 h and then resume normal daily dose. |
| Major surgical stress (ie, total proctocolectomy, open heart surgery) | Take usual morning steroid dose + 100 mg hydrocortisone IV before induction + 50 mg hydrocortisone every 8 h for 24 h and then taper dose by ½ each day until reaching maintenance level. |

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# Herbal and Dietary Supplements

Avoid the use of ephedra (Ma Huang) at least 24 hours prior to surgery due to the increased risk of heart attack and stroke. Garlic supplements can increase the risk of bleeding and should be discontinued at least 7 days prior to surgery. Ginkgo can also increase bleeding and should be stopped at least 36 hours before surgery. Ginseng lowers blood glucose and may increase risk of bleeding and should be stopped at least 7 days prior to surgery. Kava can increase the sedative effect of anesthetics and has been associated with fatal hepatotoxity and so should be stopped at least

24 hours before surgery. St. John's wort can expedite the metabolism of some drugs (induction of cytochrome P450) and should be discontinued at least 5 days prior to surgery. Valerian is associated with benzodiazepinelike withdrawal and can increase the sedative effects of anesthetics; this medication should be tapered weeks before surgery. Echinacea is associated with allergic reactions and immune stimulation. There are no current data on preoperative discontinuation.

# ENHANCED RECOVERY AFTER SURGERY PROTOCOLS

The enhanced recovery system is an integrated multidisciplinary protocol to expedite postoperative recovery. Use of this protocol, first evaluated in colorectal surgery, demonstrated a reduction in length of stay, a significant decrease in complications, and significant cost saving. Studies in gynecologic surgery have demonstrated significant improvements in length of stay, patient satisfaction, and decreased cost. Enhanced Recovery after Surgery (ERAS) guidelines for gynecologic oncology surgery were published in 2016 and are summarized in **TABLE 2.10**. Essential components of the surgical pathway include comprehensive patient education regarding goals and postoperative expectations; limited preoperative fasting and use of oral carbohydrate and electrolyte fluids prior to surgery; multimodal pain control including nonopioid analgesic agents and regional anesthesia; and resumption of normal diet and activity immediately after surgery. In 2021, the AAGL expanded these guidelines with recommendations for laparoscopic and vaginal procedures for both benign and malignant conditions.

## TABLE 2.10
## ERAS Guidelines for Gynecologic Oncology Surgery

| ITEM | RECOMMENDATION | EVIDENCE LEVEL | RECOMMENDATION GRADE |
|---|---|---|---|
| ***Preoperative*** | | | |
| Patient education and counseling | Dedicated preoperative counseling. | Low | Strong |
| Preoperative optimization | Smoking and alcohol consumption (alcohol abusers) should be stopped 4 wk before surgery.<br>Anemia should be actively identified, investigated, and corrected preoperatively. | Smoking: High<br>Alcohol: Moderate<br>Anemia: High | Strong |
| Preoperative bowel preparation | Mechanical bowel preparation should not be used routinely (even when bowel resection is planned). | Moderate | Strong |
| Preoperative fasting and carbohydrate treatment | Clear fluids should be allowed up to 2 h and solids up to 6 h prior to induction of anesthesia.<br>Carbohydrate loading reduces postoperative insulin resistance and should be used routinely. | Solids/fluids: High<br>Carb loading: Moderate | Strong |
| Preanesthesia medication | Routine administration of sedative (to reduce anxiety preoperatively) should be avoided. | Low | Strong |
| Thromboembolism prophylaxis | Patients at risk of VTE should receive prophylaxis (**see TABLE 2.6**).<br>Patients on hormone replacement therapy or oral contraceptives should discontinue the medication or consider alternatives before surgery. | VTE: High<br>HRT: Low<br>OCPs: High | Strong |
| Antimicrobial prophylaxis and skin preparation | IV antibiotics should be administered routinely within 60 min before skin incision; additional doses should be given during prolonged operations or if severe blood loss occurs.<br>Hair clipping is preferred if hair removal is mandatory.<br>Chlorhexidine-alcohol is preferred to aqueous povidone-iodine solution for skin cleansing. | High<br>High<br>High | Strong |
| ***Intraoperative*** | | | |
| Standard anesthetic protocol | Short-acting anesthetic agents should be used to allow rapid awakening.<br>A ventilation strategy using tidal volumes of 5-7 mL/kg with a PEEP of 4-6 cm $H_2O$ should be employed to reduce postoperative pulmonary complications. | Low<br>Moderate | Strong |
| Postoperative nausea and vomiting | A multimodal approach to postop nausea and vomiting with >2 antiemetic agents should be used. | Moderate | Strong |
| Minimally invasive surgery (MIS) | When possible, MIS is recommended for appropriate patients when expertise and resources are available. | Morbidity: Low<br>Recovery: High | Strong |
| Nasogastric intubation | Routine nasogastric intubation should be avoided. | High | Strong |
| | If inserted intraoperatively, nasogastric tubes should be removed before reversal of anesthesia. | High | |
| Preventing intraoperative hypothermia | Maintenance of normothermia with suitable active warming devices should be used routinely. | High | Strong |
| Perioperative fluid management | Very restrictive or liberal fluid regimes should be avoided in favor of euvolemia. | High | Strong |
| | In major open surgery and for high-risk patients where there is large blood loss (>7 mL/kg) or a SIRS response, the use of advanced hemodynamic monitoring is recommended to facilitate individualized fluid therapy and optimize oxygen delivery. | Moderate | |
| ***Postoperative*** | | | |
| Prophylaxis against thromboembolism | Patients should wear intermittent pneumatic compression stockings. | High | Strong |
| | Extended VTE prophylaxis (28 d) should be given to patients after laparotomy for abdominal or pelvic malignancies. | High | |

| | | | |
|---|---|---|---|
| Postoperative fluid therapy | Intravenous fluids should be terminated within the first 24 h; balanced crystalloids are preferred to 0.9% normal saline. | Moderate | Strong |
| Perioperative nutritional care | A regular diet within the first 24 h is recommended. | High | Strong |
| Prevention of postoperative ileus | The use of postoperative laxatives should be considered. | Low | Weak |
| | The use of chewing gum should be considered. | Moderate | Weak |
| Postoperative glucose control | Maintain blood glucose levels <180-200 mg/dL. Levels >200 should be treated with insulin infusions. | High | Strong |
| | Monitor blood glucose to avoid hypoglycemia. | High | |
| Postoperative pain analgesia | Multimodal approach to analgesia should be adopted (NSAIDs, acetaminophen, gabapentin, dexamethasone) unless a contraindication exists. | Multimodal: High<br>NSAIDs/aceta: High<br>Gabapentin: Moderate<br>Dexamethasone: Low | Strong |
| Peritoneal drainage | Not recommended in patients undergoing lymphadenectomy or bowel surgery. | Moderate | Strong |
| Urinary drainage | Urinary catheters should be used for a short period (eg, <24 h). | Low | Strong |
| Early mobilization | Patients should be encouraged to ambulate within 24 h of surgery. | Low | Strong |

Adapted from Nelson G, Altman AD, Meyer LA, et al. Guidelines for pre- and intraoperative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) society recommendations-part I. *Gynecol Oncol*. 2016;140(2):313-322. Copyright © 2015 The Authors, with permission from Elsevier.

# USE OF TELEMEDICINE IN PREOPERATIVE CARE

Telemedicine is defined by the Federation of State Medical Boards as “the practice of medicine using electronic communication, information technology, or other means between a physician in one location, and a patient in another location, with or without an intervening health care provider.” It can include real-time video visits, telephone visits, remote patient monitoring, and asynchronous communication (store and forward) or sharing of still images for diagnosis and treatment. Telehealth describes the much broader use of electronic communication for clinical care as well as education, public health, and health administration.

Within Obstetrics and Gynecology, telehealth visits have been implemented in a variety of patient encounters including well-woman visits, postoperative care, preconception counseling, family planning, prenatal care, cervical cancer screening, and abortion care. Within the field of surgical gynecology, there is a paucity of literature

addressing telehealth for preoperative care of the surgical patient. Outcomes may be extrapolated from the greater body of literature within surgical specialties and anesthesia literature, however. A meta-analysis examining the use of telemedicine in surgery noted benefits with preoperative assessment and evaluations, postsurgical care, and follow-up visits. Patient benefits included reduction of travel time and related costs as well as reduction in work absence. Importantly, telemedicine visits were not associated with increased or delayed postoperative complications.

Telemedicine has similarly been implemented into anesthesia preoperative evaluations with comparable findings. Several studies have shown feasibility, high patient satisfaction, and direct patient cost savings. In the absence of a physical exam, telemedicine visits did not result in higher case cancellations when compared to in-person visits. Video assessments of airway difficulty and heart and lung examinations were comparable to day of surgery examinations. Similar outcomes were noted in patients with a higher American Society of Anesthesiologist classifications of 3 and 4. A large proportion of gynecologic patients including oncology patients were included in these studies with favorable outcomes

# KEY POINTS

- Once the patient and surgeon have mutually made the decision to proceed with surgery, the surgeon should assess the patient's pathology and comorbidities to assess the risk of intraoperative and postoperative complications.
- Preoperative evaluation may involve collaboration among the surgeon, anesthesiologist, primary care provider, and medical specialists to optimize the patient's condition prior to surgery.
- Routine preoperative laboratory testing in a healthy population undergoing elective surgery is unlikely to change clinical management. Selective preoperative testing before gynecologic surgery should be individualized to the patient and the planned surgical procedure.

- Most medications can be continued up until the day of surgery. Some medications need to be held to avoid intraoperative or postoperative complications.
- All herbal supplements should be avoided around the time of surgery.
- Enhanced Recovery After Surgery protocols are recommended to improve surgical outcomes and expedite recovery.

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# SECTION II

# Basic Principles of Gynecologic Surgery


3 **Anesthesia Primer for the Gynecologist**
Christine P. McKenzie

4 **Radiology Primer for the Gynecologist**
Ersan Altun and Kristen Olinger

5 **Patient Positioning for Pelvic Surgery**
Kimberly Kenton and Margaret G. Mueller

6 **Surgical Techniques, Instruments, and Suture**
John T. Soper

7 **Principles of Electrical and Laser Energy Applied to Gynecologic Surgery**
Magdy P. Milad and Ted L. Anderson

8 **Incisions for Gynecologic Surgery**
James J. Burke II

9 PRINCIPLES OF LAPAROSCOPY
Amanda Yunker

10 PRINCIPLES OF ROBOTIC SURGERY
Arnold P. Advincula and Sierra J. Seaman

# CHAPTER 3

# ANESTHESIA PRIMER FOR THE GYNECOLOGIST

Christine P. McKenzie

**Basic Anesthesia Concepts**

Anesthesia Care Team

Standard Anesthesia Monitoring

The Continuum of Consciousness

**Preoperative Assessment and Optimization**

Risk Assessment

Airway Evaluation

Perioperative Fasting Guidelines

Anesthesia for High-Risk Patients

**Conduct of Anesthesia**

Advanced Monitoring

General Anesthesia

Regional Anesthesia

**Fluid Management and Blood Component Therapy**

Perioperative Fluid Administration

Managing Blood Loss

**Special Considerations for Laparoscopic or Robotic Procedures**

Positioning

Changes Related to $CO_2$ Insufflation

Optimizing Ventilation for Laparoscopic and Robotic Surgery

Perioperative Complications

**Enhanced Recovery Methods**

The goals of an individual anesthetic are to ensure patient comfort and safety while providing the surgical teams with the patient condition needed to complete the necessary or desired procedure. However, the entity of anesthesia itself is complicated and can be overwhelming. Understanding these principles will allow you to better prepare your patients for surgery and communicate your needs and concerns to the anesthesia care team (ACT).

# BASIC ANESTHESIA CONCEPTS

## Anesthesia Care Team

The practice of anesthesiology includes perioperative consultation, management of coexisting disease, treatment of acute and chronic pain, and critical care medicine. In the perioperative setting, patient care is either personally provided or directed by a physician anesthesiologist. Additional nonphysician anesthesia providers are critical members of the health care system to allow for efficient and safe care of surgical patients. The term used to describe the model of nonphysician anesthesia providers medically directed or supervised by an anesthesiologist is the ACT. In 1982 the American Society of Anesthesiologist (ASA) publication, “Statement on the Anesthesia Care Team,” first defined concepts and minimal standards for the care team model (last amended in October 2019). **TABLE 3.1** describes the level of training and role of various anesthesia personnel as well as other terms used for perioperative care models. It is the stance of the ASA that the perioperative care of every patient includes an anesthesiologist. The delegation of tasks to

nonphysician providers should be defined by the anesthesiologist and should abide by state law and institutional policy. A physician is responsible for performing a preanesthetic evaluation, determining medical readiness for anesthesia and surgery, and providing critical care management for unexpected emergencies. Throughout the chapter, the term anesthesiologist is used when the tasks being discussed are the responsibility of a physician anesthesiologist. The term anesthesia provider is used when either an anesthesiologist or a nonphysician anesthesia provider performs the described tasks.

## TABLE 3.1
## Anesthesia Care Team

| |
|---|
| **a. Physicians** |
| ANESTHESIOLOGIST: **Director of the Anesthesia Care Team**; a **physician** licensed to practice medicine who has successfully completed a training program in anesthesiology accredited by the ACGME, the American Osteopathic Association or equivalent organizations. |
| ANESTHESIOLOGY FELLOW: An **anesthesiologist** enrolled in a training program to obtain additional education in one of the subdisciplines of anesthesiology. |
| ANESTHESIOLOGY RESIDENT: A **physician** enrolled in an accredited anesthesiology residency program. |
| **b. Nonphysicians** |
| ANESTHETIST: A **nurse anesthetist** or **anesthesiologist assistant**, as each is defined below. (Note: In some countries where nonphysicians do not participate in the administration of anesthesia, a physician who practices anesthesiology is known as an "anaesthetist" or "anesthetist"). |
| NURSE ANESTHETIST: A **registered nurse** who has satisfactorily completed an accredited nurse anesthesia training program and certifying examination (also, "CRNA"). |
| ANESTHESIOLOGIST ASSISTANT: A **health professional** who has satisfactorily completed an accredited anesthesiologist assistant training program and certifying examination (also, "CAA"). |
| STUDENT NURSE ANESTHETIST: A **registered nurse** who is enrolled in an accredited nurse anesthesia training program (also, "SRNA"). |
| ANESTHESIOLOGIST ASSISTANT STUDENT: A **health profession graduate student** who has satisfied all prerequisite undergraduate coursework typically required for entry into an accredited school of medicine and is enrolled in an accredited anesthesiologist assistant training program. |
| NONPHYSICIAN ANESTHESIA STUDENT: Student nurse anesthetists, anesthesiologist assistant students, dental anesthesia students, and others who are enrolled in accredited anesthesia training programs. |
| MEDICAL STUDENT: A student enrolled in an accredited allopathic or osteopathic medical school. |
| OTHERS: Although not considered core members of the ACT, other health care professionals make important contributions to the perioperative care of the patient. |

Excerpted from the "Statement on the Anesthesia Care Team, 2019" of the American Society of Anesthesiologists. A copy of the full text can be obtained from ASA, 1061 American Lane Schaumburg, IL 60173-4973 or online at www.asahq.org

# Standard Anesthesia Monitoring

The ASA statement, "Standards for Basic Anesthetic Monitoring," summarizes the minimal standards for patient monitoring. The

interface between the anesthesia provider and each patient utilizes an increasingly complex anesthesia delivery system (ADS) (**FIG. 3.1**). Patient oxygenation must be continuously monitored, regardless of anesthetic technique. Ventilation is also monitored during general anesthesia (GA) utilizing a monitor for end-tidal carbon dioxide ($ETCO_2$). During controlled ventilation, there must be a device capable of detecting breathing component disconnection. When procedures are completed using regional anesthesia or local anesthesia only, ventilation is observed using qualitative clinical signs. If moderate or deep sedation is utilized, exhaled carbon dioxide ($CO_2$) is meticulously monitored. During all anesthetics, circulatory monitoring including continuous electrocardiogram (ECG) tracing, and blood pressure (BP) and heart rate (HR) are assessed at least every 5 minutes. When GA is utilized, adequacy of circulation is monitored by continual palpation of a pulse, an indwelling arterial catheter, ultrasound peripheral pulse monitoring, or pulse oximetry. Patient temperature is also followed when significant temperature changes are possible or expected. These are the basic standards for administration of anesthetic and may be exceeded based on the clinical judgment of the anesthesiologist.

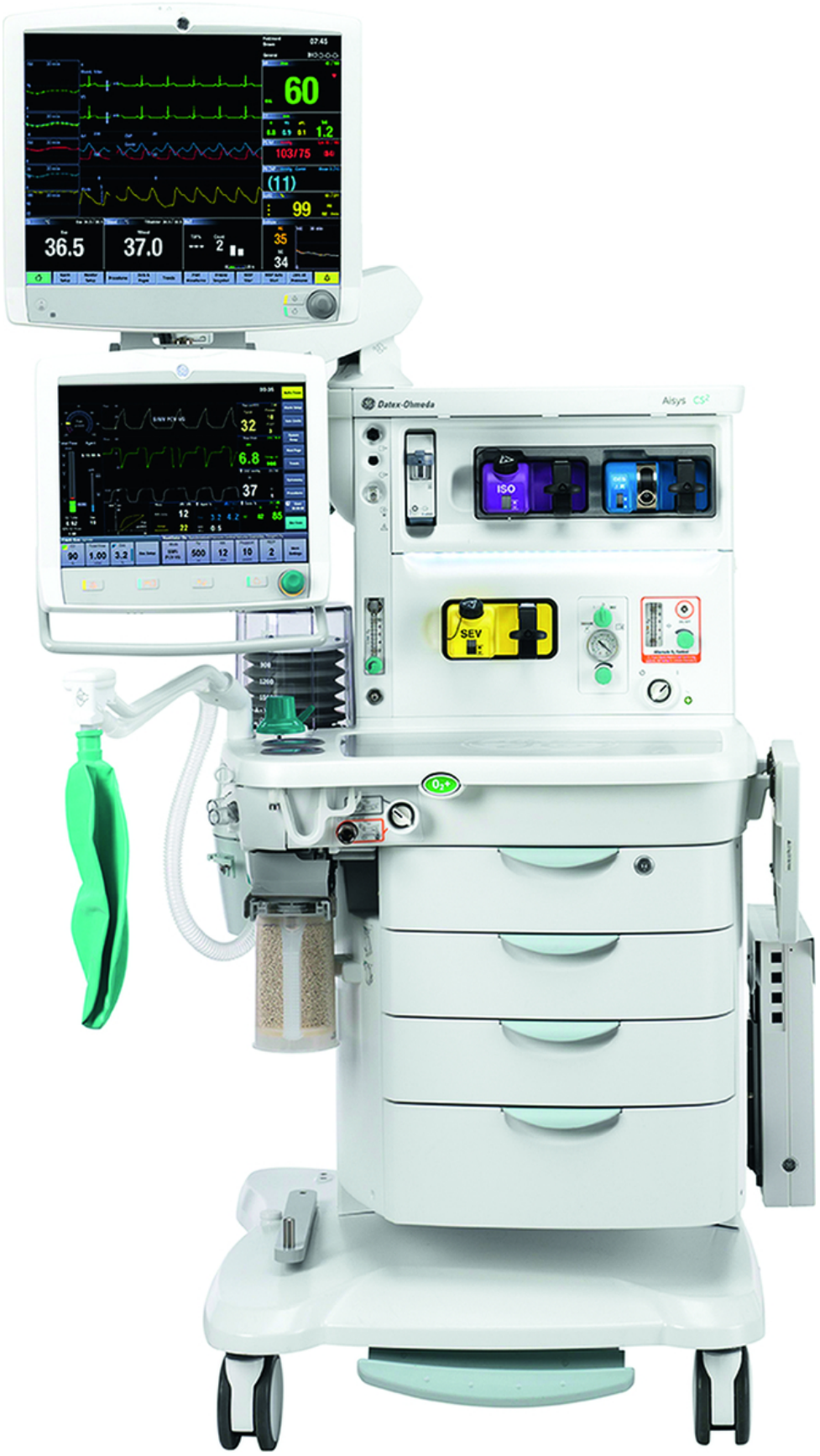
60
103/75
(11)
99
36.5
37.0
35
34
32
6.8
37
Datex-Ohmeda
Aisys CS²
ISO
SEV
O₂+

**FIGURE 3.1** Anesthesia delivery system; typical configuration with physiologic monitors. (Aisys™ CS$^2$ Anesthesia Delivery System image courtesy of GE HealthCare.)

# The Continuum of Consciousness

There is a continual depth of sedation or anesthesia that patients can experience and are tailored for various surgical procedures. Gynecological procedures performed outside of the operating room environment requiring sedation should be performed within the parameters set by the Joint Commission. The Center for Medicare and Medicaid Services has mandated that all sedation in a hospital should be under the direction of a physician (**TABLE 3.2**).

## TABLE 3.2
## Depths of Sedation

| LEVEL | | RESPONSIVENESS | AIRWAY | SPONTANEOUS VENTILATION | CARDIOVASCULAR FUNCTION |
|---|---|---|---|---|---|
| 1 | Minimal | Normal response to verbal stimulus | Unaffected | Unaffected | Unaffected |
| 2 | Moderate | Purposeful response to verbal or tactile stimulus | No intervention required | Adequate | Usually maintained |
| 3 | Deep | Purposeful after repeated or painful stimulus | Intervention may be required | May be inadequate | Usually maintained |
| 4 | General anesthesia | Unarousable to painful stimulus | Intervention often required | Often inadequate | May be impaired |

For monitored anesthesia care (MAC), or conscious sedation, patients are not completely asleep and are not intubated. Varying levels of sedation are administered depending on needs of the procedure. MAC is performed by anesthesia-trained personnel who are can quickly induce general anesthesia if needed. Procedural and personnel factors such as procedure duration, invasiveness, the availability and training of additional personnel, the location of the procedure, and the level of training of the person providing the

sedation determine the level of sedation and the medications that can be used. Patient factors that need to be considered include the degree of anxiolysis and analgesia required, medication history (drug interactions or tolerance), comorbidities, and age. If (1) the procedure is not very stimulating or (2) the painful stimulus can be interrupted with regional or local anesthesia, the procedure can be attempted with sedation. An example of this would be a dilation and curettage with a paracervical block in place. Patient selection is also an important factor for determining MAC.

Patients at high risk for airway obstruction (patients with morbid obesity or obstructive sleep apnea) or patients at increased risk of aspiration (pregnant patients at >16 weeks' gestation) are poor candidates for deep sedation.

# PREOPERATIVE ASSESSMENT AND OPTIMIZATION

## Risk Assessment

The preoperative evaluation aims to reduce the risk of perioperative complications and the morbidity associated with surgery and administration of anesthesia. Key elements of the preanesthetic evaluation include a review of the planned surgical procedure and its indication, present and past medical history, current medications and drug allergies, use of alcohol, tobacco, or illicit drugs, and response to previous anesthetics. A focused physical examination is also important to assess surgical and anesthetic risks. Anesthesiologists use the ASA physical status classification system to summarize the health status of individual patients (**TABLE 3.3**).

### TABLE 3.3
### American Society of Anesthesiologists Physical Status Classification System

| ASA PHYSICAL STATUS CLASSIFICATION | | EXAMPLES |
|---|---|---|
| 1 | Normal healthy person | |
| 2 | Mild systemic disease that results in no functional limitation | Current smokers, social alcohol users, classes I and II obesity (30 < BMI < 40), mild lung disease, well-controlled DM or HTN |
| 3 | Severe systemic disease that results in functional limitation | Poorly controlled DM or HTN, COPD, class III obesity (BMI > 40), moderately reduced EF, history of (>3 mo ago) MI, CVA, TIA, and CAD/stents |
| 4 | Severe systemic disease that causes a constant threat to life | Recent (<3 mo ago) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valvular disease, sepsis, DIC, or AKI |
| 5 | Moribund patient not expected to live without the planned surgery | Massive trauma, ischemic bowel, ruptured AAA |
| 6 | Brain-dead person whose organs are being removed for donor purposes | |
| E | Qualifier for emergent procedures | |

BMI, body mass index (kg/m$^2$); DM, diabetes mellitus; HTN, hypertension; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; MI, myocardial infarction; CVA, cerebrovascular accident; TIA, transient ischemic attack; CAD,

coronary artery disease; DIC, disseminated intravascular coagulation; AKI, acute kidney injury; AAA, abdominal aortic aneurysm.

Surgical procedures are assigned one of three levels of urgency: elective (no level of urgency and delaying the procedure would be of minimal or no risk to the patient), urgent (surgery for acute onset or clinical deterioration of potentially a life-threatening condition), and emergent (immediate surgery is needed to correct a life-threatening or limb-threatening condition). Surgical procedures performed for urgent or emergent conditions are associated with an increased risk of morbidity and mortality. Procedures can also be time-sensitive procedure. Time-sensitive procedures are procedures in which delaying the intervention would potentially place the patient at increased risk (ie, surgery for a malignant condition). The type of planned procedure and category of urgency will alert the anesthesiologist to the type of anesthesia needed, the level of expected postoperative pain, the necessary patient positioning, expected blood loss, and monitoring requirements. Understanding these factors as well as the patient condition allows the provider to determine perioperative risk and provide optimal care.

# Airway Evaluation

A critical component of the preanesthetic evaluation is a thorough evaluation of the patient's airway. The evaluation also includes reviewing prior anesthetic records, a physical examination, and a patient-reported history. An assessment is made of the potential for difficulty with mask ventilation or intubation as well as the risk of aspiration when developing an anesthetic induction and airway plan. There is no single physical examination finding that predicts a patient's likelihood of having a difficult airway; however, risks increase when multiple factors are present. Factors that are associated with increased risk of difficult intubation or mask ventilation include a history of failed or traumatic airway management, dental damage or prolonged airway soreness after a prior anesthetic, history of head/neck surgery or radiation therapy, obstructive sleep apnea (OSA), cervical spine pathology or limited

range of motion, or temporomandibular joint disease. Independent predictors for difficult mask ventilation include the presence of a beard, body mass index (BMI) >26 kg/m$^2$, lack of teeth, age >55 years, and a history of snoring. Factors increasing a patient's risk of aspiration include recent oral intake, acute trauma, acute gastrointestinal (GI) pathology, acute opioid therapy, significant gastroesophageal reflex, current intensive care admission, pregnancy (gestational age >16 weeks), patients in the immediate postpartum period, and systemic diseases associated with gastroparesis (diabetes mellitus [DM], collagen vascular disease, advanced Parkinson disease).

# Perioperative Fasting Guidelines

Pulmonary aspiration is estimated to occur in 1 in 3000 to 6000 elective cases but occurs in up to 1 in 600 emergency anesthetics. For aspiration to occur, there must be a sufficient volume of gastric contents to be regurgitated, the protective tone of the lower esophageal sphincter is impaired, and the upper airway reflexes that close the glottis are suppressed. With the use of sedative medications or GA, the tone of the lower esophageal sphincter and upper airway reflexes will be relaxed. The only modifiable factor for perioperative patients is the volume of the gastric contents. Therefore, preoperative and preanesthesia fasting is critical to minimize the risk of pulmonary aspiration of gastric contents. The most recent ASA perioperative fasting guidelines published in 2017 are shown in **TABLE 3.4**. The "safe" volume of gastric contents to reduce the risk of aspiration and the exact duration of perioperative fasting to reduce the volume of gastric contents is not known; however, these guidelines incorporate the best evidence for the duration of fasting needed to reduce perioperative risk. The use of point of care preoperative gastric ultrasound to determine gastric volume is one way to quantitate gastric contents. The role of gastric ultrasound for perioperative assessment has not been clearly defined but is becoming more frequently used in clinical practice to assess potential aspiration risk.

## TABLE 3.4
## Perioperative Fasting Guidelines

| INGESTED SUBSTANCE | MINIMUM FASTING PERIOD (h) |
|---|---|
| Clear liquids (water, carbonated beverages, juice,[a] tea, black coffee, electrolyte/sports beverages) | 2 |
| Breast milk | 4 |
| Infant formula | 6 |
| Nonhuman milk | 6 |
| Light meal (toast and clear liquids) | 6 |
| Heavy meal (fatty foods) | 8 |

[a]Fruit juices without pulp.

# Anesthesia for High-Risk Patients

A preoperative anesthesia consultation refers to an evaluation by an anesthesiologist in the days or weeks prior to surgery, typically performed in a preoperative consultation clinic. A preoperative anesthetic consultation presents many opportunities to influence and optimize perioperative care. **FIGURE 3.2** is an example of an algorithm from our institution for determining whether a preanesthetic consultation or evaluation is indicated.

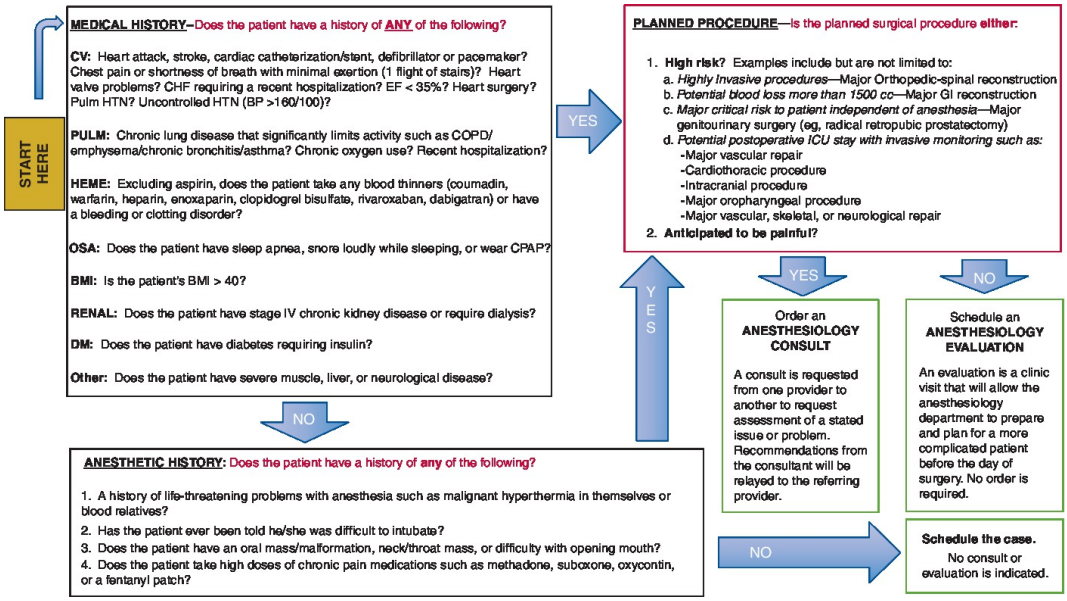


**FIGURE 3.2** An example of an algorithm from the University of North Carolina preoperative care clinic for determining the need for a preoperative evaluation or consultation prior to the day of surgery by an anesthesiologist. See Table 3.3 legend for abbreviations. CHF congestive heart failure, BP blood pressure, OSA obsturctive sleep apnea.

Malignant hyperthermia (MH) is a rare and life-threatening clinical syndrome occurring in susceptible individuals following anesthetic exposure. The medications known to trigger MH are succinylcholine and inhalational anesthetics. The susceptibility to MH is genetic. In susceptible individuals, the exposure to triggering agents causes an excessive release of calcium ions within muscle cells leading to muscle contraction and a hypermetabolic state. Signs and symptoms of MH include increased $CO_2$ production, increased $O_2$ consumption, acidosis, muscle rigidity, tachycardia, hyperthermia, and rhabdomyolysis. Treatment includes immediate cessation of all MH-triggering agents, treatment with dantrolene, cooling maneuvers, and

supportive measures. If there are any concerns about a personal or family history of MH, the patient should be referred for a preoperative anesthetic consultation.

Obesity-related conditions include DM, cardiovascular disease, OSA, nonalcoholic fatty liver disease, and osteoarthritis. Surgery for the obese patient requires careful consideration of these related conditions, preoperative planning, perioperative risk assessment and optimization, strict adherence with venous thrombosis prophylaxis, and effective postoperative pain control. **TABLE 3.5** shows anesthetic considerations specific to the obese patient.

## TABLE 3.5
## Anesthetic Implications for the Obese Patient

Respiratory System

- Increased risk of hypoxia with apnea or hypoventilation (decreased ventilatory compliance, TV, FRC, and VC)
- Increased atelectasis and hypoxia (truncal obesity impacts diaphragm position and movement)
- Increased peak airway pressures needed for mechanical ventilation
- Increased MV (increased $O_2$ consumption and $CO_2$ production due to increased metabolic activity)
- Increased RR in response to increased ventilatory requirements (respiratory mechanics do not allow for significant increases in TV and therefore rely on RR to increase MV)
- Increased incidence of OSA and OHS[a]
- Increased risk for sedative- or opioid-related ventilatory impairment

Cardiovascular System

- Increased incidence of CV sequelae (HTN, LVH, diastolic dysfunction, and HF)
- Increased BV

Endocrine System

- Increased risk for perioperative hyperglycemia (high incidence of DM and insulin resistance)

Airway

- Increased incidence of difficulty airways (large tongue, perimandibular fat tissue, and redundant pharyngeal soft tissue)
- Increased risk of aspiration
- Increased incidence of difficulty with mask ventilation

Pharmacologic

- Altered medication dosing[b] (increased total body fat, altered protein-binding, BV, and CO)
- Prolonged medication effect from lipophilic medications (increased fat stores)

Other

- Difficulty with patient positioning
- Difficulty with vascular access
- Difficulty with accuracy of monitoring equipment due to improper sizing/design
- Challenging placement for neuraxial or regional anesthesia procedures

[a]OHS is defined as daytime hypercapnia and hypoventilation and sleep disordered breathing.

[b]Drugs distributed to lean tissues should be dosed on lean body weight (LBW) (=ideal body weight × 1.2); lipophilic drugs may be initially dosed on LBW initially but require total body weight to be used for maintenance.

TV, tidal volume; FRC, functional residual capacity; VC, vital capacity; MV, minute ventilation; RR, respiratory rate; OSA, obstructive sleep apnea; OHS, obesity hypoventilation syndrome; CV, cardiovascular; HTN, hypertension; LVH, left ventricular hypertrophy; HF, heart failure; BV, blood volume; DM, diabetes mellitus; CO, cardiac output.

Aging is the gradual and cumulative process of damage and deterioration. The goals for postoperative management are not different in the elderly patient however, the goals may be more challenging. **e-TABLE 3.1 shows the physiologic changes found in the elderly and the associated perioperative implications**. One major perioperative concern for elderly patients is postoperative delirium and cognitive dysfunction or decline. The occurrence of a perioperative neurocognitive disorder is believed to affect 10%-40% of all patients over 60 years of age. It is recommended that all patients over the age of 65 be informed of the risks of perioperative neurologic dysfunction following surgery. Preexisting cognitive dysfunction is a risk factor; therefore, baseline cognitive assessment with a brief screening tool is recommended for all patients over the age of 65. While there is a lack of evidence to support any one anesthetic technique to reduce patient risk, the medications listed in **TABLE 3.6** should be used with caution or avoided in the elderly population. Elderly patients require lower concentrations of anesthetic medications to achieve the same depth of anesthesia compared to younger patients. Using age-adjusted anesthetic concentrations, optimizing cerebral perfusion (ie, avoiding hypotension), and performing an EEG-based anesthetic using an EEG monitor are recommended to reduce the risk of perioperative neurocognitive dysfunction and monitor depth of sedation. Administration of inadequate analgesia has been associated with delirium as well as sleep deprivation, respiratory impairment, ileus, immobility, insulin resistance, tachycardia, and hypertension. Elderly

patients are prone to have inadequate pain control and experience adverse effects related to pain. Programs focusing on comprehensive perioperative care like enhanced recovery after surgery (ERAS) programs can improve recovery and postoperative outcomes for all patients, including elderly patients.

## e-TABLE 3.1 Physiologic Changes and Anesthetic Implications for the Elderly Patient

| PHYSIOLOGIC CHANGES | EFFECT | PERIOPERATIVE IMPLICATIONS |
|---|---|---|
| *Body Composition* | | |
| Gradual loss of skeletal muscle and increased body fat | • Decreased volume of distribution | • Increased blood concentrations of medications due to decreased uptake from muscle |
| Loss of total body water | | |
| Decrease in basal metabolism | • Decreased heat production | |
| *Hepatic System* | | |
| Decrease (20%-40%) in liver blood flow | • Modest reduction in phase I metabolism | • Reduced liver metabolism and clearance of medications |
| *Renal System* | | |
| Reduction in renal cortical mass and glomeruli | • Reduced GFR 1 mL/min/y after age 40 | • Reduced renal excretion of medications |
| *Endocrine* | | |
| Decreased insulin secretion | • Increased incidence of hyperglycemia | • Increased need for insulin use perioperatively |
| *Central Nervous System* | | |
| Decrease in brain mass beginning at age 50 (rapid decreases later in life) | • Decreased response time | • Increased sensitivity to anesthetic agents |
| Decreased neurotransmitter function | • More difficulty with new learning<br>• After age 85, nearly 50% of patients will have significant cognitive impairments | • 6% decrease in MAC per decade<br>• Increased risk of postoperative delirium and/or cognitive decline[a] |
| *Cardiovascular System* | | |
| Decreased cardiac responsiveness to adrenergic stimulus<br>Decreased response to β-receptor stimulation<br>Stiffening of the myocardium, arteries, and veins<br>Increased sympathetic and decreased parasympathetic activity | • Low maximal heart rate (and cardiac output)<br>• Lack of heart rate response to hypotension<br>• Impaired diastolic filling<br>• Increased reliance on atrial kick (sinus rhythm for cardiac filling)<br>• Decreased venous buffering capacity<br>• Widened pulse pressure<br>• Increased myocardial wall stress and oxygen consumption | • Increased blood pressure lability with sympathetic activation from surgical stimulus<br>• Increased prevalence of hypotension from anesthetic-induced vasodilation<br>• Increase prevalence of diastolic dysfunction and risk of CHF<br>• Increased sensitivity to volume changes<br>• Decreased exertional capacity<br>• Decreased responsiveness to β-agonists |
| Conduction system changes | • Increased incidence of SSS, conduction blocks, and atrial fibrillation | |
| Defective ischemic preconditioning | • Lack of ability to tolerate periods of myocardial ischemia | • Decreased exertional capacity |
| *Pulmonary System* | | |

| | | |
|---|---|---|
| Increased stiffness of the chest wall<br>Decreased stiffness of the lung parenchyma<br>Flattening of the diaphragm | • Increased work of breathing | • Increased incidence of fatigue/respiratory failure when challenged by the need to increase minute volume |
| Increased closing capacity<br>Increased functional residual capacity<br>Increased ventilation-perfusion mismatch | • Increased incidence of small airway collapse<br>• Decreased resting $PaO_2$<br>• Reduced airflow on forced exhalation | • Increased atelectasis and hypoxia |
| Decreased in response to hypercapnia and hypoxia | • Increased incidence of sleep disordered breathing | • Increased risk of hypoxia postoperatively |
| Less effective coughing and impaired swallowing | | • Increased risk of aspiration |
| *Thermoregulation* | | |
| Impaired temperature regulation (ie, vasoconstriction, shivering)<br>Decreased basal metabolic rate | • Decreased heat production | • Increased incidence of perioperative hypothermia |

[a]Related to the interaction of anesthesia, the stress/inflammatory changes of surgery, and age-related nervous system changes. GFR, glomerular filtration rate; MAC, minimal alveolar concentration; CHF, congestive heart failure; $PaO^2$, partial pressure of $O^2$ in arterial blood.

## TABLE 3.6
## Medications to Use With Caution in the Elderly Patient

| |
|---|
| First-generation antihistamines (diphenhydramine) |
| Phenothiazine-type antiemetics (prochlorperazine, promethazine) |
| Antispasmodics/anticholinergics (atropine, scopolamine) |
| Antipsychotics (haloperidol) |
| Benzodiazepines (midazolam, diazepam) |
| Corticosteroids (hydrocortisone, methylprednisolone) |
| $H_2$-receptor antagonists |
| Metoclopramide |
| Meperidine |
| Skeletal muscle relaxants (cyclobenzaprine) |

# CONDUCT OF ANESTHESIA

## Advanced Monitoring

For all procedures except operations performed under local anesthesia without sedation, the ASA basic monitoring standards must be followed. BP monitoring in the majority of gynecologic surgeries is monitored adequately with a noninvasive oscillometric blood pressure (NIBP) cuff on the upper extremity. In cases in which the arms are tucked at the patient's side, a backup NIBP cuff is typically placed on the other arm since access to tucked arms can be more difficult. The most common enhanced monitor that is utilized in major gynecologic surgery is an intra-arterial catheter (arterial line) for which the incidence of severe complications such as infection or ischemia and tissue necrosis is extremely low. The most common indication for placement of an arterial line is the need for more frequent BP measurements than the 5-minute interval as described in the ASA Basic Monitoring Standards. This is indicated in patients with decompensated heart failure, significant ischemic heart disease, or cerebrovascular disease.

Pulse pressure variation (PPV) in mechanically ventilated patients is a dynamic marker for intravascular volume status. During ventilation, intrathoracic pressure changes impact cardiac filling. During spontaneous ventilation, the intrathoracic pressure is negative during inspiration transiently increasing venous return and BP. During positive pressure ventilation, the opposite occurs during inspiration, and there is a decrease in venous return. Increases in PPV indicate that the patient is volume responsive and suggests the need for intravascular volume repletion. The use of Trendelenburg position and intraperitoneal insufflation does not appear to affect the PPV. Most anesthesia monitoring systems have PPV monitoring capability. The enhanced information obtained from an arterial line does not require additional equipment.

Although there is no requirement to monitor the depth of anesthesia beyond measuring the concentration of intravenous (IV) or inhaled anesthetics some patients will benefit from the utilization of a processed electroencephalographic (EEG) monitor. The

bispectral index (BIS) is the most commonly used processed EEG technique in North America. A BIS sensor is placed across the surface of a patient's forehead, and the sensor derives a number based on quantifying EEG signals and frequencies. The derived number alerts the anesthesia provider to the depth of sedation. BIS monitoring can be helpful in minimizing intraoperative recall and reducing recovery time.

# General Anesthesia

GA is defined as a drug-induced reversible depression of the central nervous system resulting in the loss of response to and perception of all external stimuli. However, this broad definitive is problematic because anesthesia is not simply a deafferented state with amnesia being an important aspect of anesthesia. Also, all anesthetics do not produce equal depression of all sensory changes. A more practical definition of the anesthetic state is defined using various components: unconsciousness, amnesia, analgesia, immobility, and attenuation of autonomic responses to noxious stimulation. **TABLE 3.7** outlines the sequence of events for a standard general anesthetic.

## TABLE 3.7
## Sequence of Events for General Anesthesia

| | DESCRIPTION |
|---|---|
| Induction | 1. Ensure standard monitors are in place and functioning properly.<br>2. Complete a preinduction verification with surgical team.<br>3. Preoxygenate the patient.<br>4. Administer induction medications and render the patient unconscious.<br>5. Initiate bag-mask ventilation.<br>6. Administer neuromuscular blocking drug prior to intubation.[a]<br>7. Intubate and confirm endotracheal tube placement by auscultation and sustained end-tidal $CO_2$.<br>8. Place any additional IV catheters or invasive monitors. |
| Maintenance | 1. Maintain anesthetic depth with a balanced technique or total intravenous anesthetic.<br>2. Monitor depth of neuromuscular blockade with train-of-four monitoring.<br>3. Administer opioids and analgesic adjuvants for postoperative analgesia.<br>4. Assess and maintain intravascular volume status.<br>5. Maintain adequate ventilation by assessing tidal volume, airway pressures, and $ETCO_2$.<br>6. Monitor vital signs and manage as indicated. |
| Emergence | 1. Ensure hemodynamic stability and normothermia.<br>2. Determine disposition and communicate with surgical team.<br>3. Reduce anesthetic depth, as surgical team is finishing procedure.<br>4. Assess train-of-four and reverse neuromuscular blockade.<br>5. Initiate spontaneous ventilation in preparation for extubation.<br>6. Extubate patient after extubation criteria are met.<br>7. Ensure adequate ventilation, oxygenation, and hemodynamic stability postextubation.<br>8. Transport patient to postoperative recovery unit. |
| Postoperative Recovery | 1. Provide detailed report of preoperative assessment, intraoperative events, and any postoperative concerns on arrival to postoperative recovery unit.<br>2. Monitor patient's mental status, level of analgesia, hemodynamic stability, and volume status.<br>3. Communicate any concerns regarding patient stability or postoperative complications with surgical team.<br>4. Once discharge criteria are met, the patient is released from the postoperative recovery unit. |

[a]If a supraglottic airway device is being used, it will be placed after loss of conscious typically without the administration of neuromuscular blocking drugs.

# *Induction*

Induction and emergence are the two most critical times of an anesthetic. At the time of induction, the anesthesiologist administers medications to render the patient unconscious. These medications have significant cardiovascular effects, diminish upper airway muscle tone leading to obstructed ventilation, and depress respiratory drive resulting in apnea. Before induction, the ACT will place the standard ASA monitors on the patient to ensure that the patient is monitored adequately and that all monitors are functioning prior to induction.

Induction is typically initiated using IV medications. In infants and small children, an inhalation induction is preferred to avoid obtaining IV access in a conscious infant. Inhalation inductions are completed by incrementally increasing the concentration of an inhaled anesthetic, typically a combination of nitrous oxide and sevoflurane, until unconsciousness occurs. Inhalational inductions can be used in adult patients who are needle phobic or those with poor peripheral

access; however, an IV induction is preferable because it is rapid and reliable.

Propofol is the most used induction agent in current anesthesia practice. Other agents include etomidate, ketamine, and methohexital. Other barbiturates and benzodiazepines can be used for induction of anesthesia but are uncommon in modern clinical practice. Propofol has a rapid onset and a short duration of action making it an ideal induction agent. Side effects include a burning sensation on injection and hypotension caused by venous dilation. Propofol does not have analgesic properties and therefore does a poor job of blunting the hemodynamic response to laryngoscopy; therefore, additional adjuvants are typically used at the time of induction including IV lidocaine and opioids. Infusion of IV lidocaine reduces the burning sensation experienced on injection of propofol and blunts the hemodynamic response to laryngoscopy (**TABLE 3.8**).

## TABLE 3.8
## Commonly Used Induction Medication

| |
|---|
| Propofol |
| Ketamine |
| Methohexital |
| Etomidate |

# *Airway Management*

Anesthetic and sedative medications impair ventilation in multiple ways by causing respiratory depression or apnea, relaxing oropharyngeal muscles leading to airway obstruction, and suppressing normal airway reflexes thereby increasing the risk of aspiration. When developing an airway plan, the anesthesiologist considers the suspected ease of rapid intubation by direct or indirect

laryngoscopy, the ease of ventilation with face mask or an SGA, the risk of aspiration, and the potential morbidity of failed airway maneuvers.

Preoxygenation or denitrogenation is the act of displacing the nitrogen content of the lungs with $O_2$; this allows for maintenance of an adequate $O_2$ saturation during periods of apnea produced by the induction of anesthesia. A patient breathing room air prior to an episode of apnea can maintain $O_2$ saturations above 90% for a maximum of 2 minutes, as opposed to up to 10 minutes with proper preoxygenation. A patient is considered adequately preoxygenated when the expired concentration of $O_2$ is >80%. This is accomplished by having a patient preoxygenate with 100% $O_2$ for 4 minutes by breathing using a tight-fitting face mask. Patients with significant cardiopulmonary disease, decreased functional residual capacity (ie, obesity, pregnancy), or increased $O_2$ consumption will desaturate more quickly even with proper preoxygenation. In patients with suspected decreased reserve, suspected difficult mask ventilation, or at increased aspiration risk (relative contraindication to mask ventilation), adequate preoxygenation becomes even more critical to maintain an adequate $O_2$ saturation in preparation for induction.

During the standard induction of GA, apnea occurs, and the anesthesia provider must support patient ventilation and oxygenation. Typically, unless contraindicated (ie, increased risk of aspiration), the anesthesia face mask is used to provide ventilation initially. The face mask can be used as the sole ventilatory support method however, only for very brief procedures. The ease of mask ventilation may determine which NMBD is used to facilitate intubation. If mask ventilation is challenging, muscle relaxation may improve the conditions and ease of mask ventilation; however, if an NMBD is administered, the patient will lose the ability to spontaneously ventilate until the NMBD is metabolized or reversed by neuromuscular reversing agents.

Intubation is the act of placing an endotracheal tube (ETT) through the larynx and into the trachea. A view of the vocal cords is required to allow for direct insertion and can be obtained using direct laryngoscopy (DL), video laryngoscopy, or fiberoptic visualization. An

adult ETT typically has a cuff at the end to seal off the trachea from the pharynx to allow for positive pressure ventilation and protect the trachea from the aspiration of gastric contents. Laryngoscopy views are described using the Cormack-Lehane grading system (**FIG. 3.3**). Positioning patients properly for intubation is critical to optimize intubating conditions. A ramp position is the ideal position for obese patients. Use of video laryngoscopy provides an indirect view of the larynx, which can aid with ETT placement especially in patients with anterior airways or limited cervical neck motion (**FIG. 3.4**). As a surgeon, it is helpful to familiarize yourself with the difficult airway algorithm to be prepared to assist the anesthesia team at this potentially critical time.

**FIGURE 3.3** The Cormack-Lehane grading system used for laryngoscopy views. Grade I, a full view of the glottis; grade II, partial view of the glottis; grade III, only epiglottis seen with no visualization of the glottis; grade IV, neither the glottis nor the epiglottis is seen. (From Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. *Anesthesia.* 1987;42(5):487-490. Copyright © 1987 The Association of Anaesthetists of Gt Britain and Ireland. Reprinted by permission of John Wiley & Sons, Inc.)

**FIGURE 3.4** Depiction of the optical axis obtained using video laryngoscopy. (From Chu LF, Fuller A. *Manual of Clinical Anesthesiology*. 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012. Figure 9.1A.)

## *Maintenance*

The maintenance phase of the anesthetic begins after induction and airway securement. The typical anesthetic is a “balanced technique” of different IV and inhalational agents. **TABLE 3.10** shows commonly

used inhalational agents, IV anesthetics, and adjuvants. Inhalational agents are the most used maintenance agents for a general anesthetic. The anesthesia provider may opt to use a total intravenous anesthetic (TIVA), which most commonly uses propofol as the predominant anesthetic maintenance agent. A TIVA technique is most commonly used in patients at high risk for postoperative nausea and vomiting (PONV). The incidence and severity of PONV is decreased with use of TIVA.

## TABLE 3.10
## Commonly Used Anesthetics and Adjuvants

| | |
|---|---|
| Inhaled | Nitrous oxide, isoflurane, sevoflurane, desflurane |
| IV anesthetics | Propofol, etomidate, ketamine |
| Adjuvants | Dexmedetomidine, midazolam, lidocaine |

During abdominal and thoracic procedures, surgeons require skeletal muscle relaxation with a paralytic agent for optimal operating conditions. NMBDs produce paralysis; however, they have no amnestic or sedative properties. Improper use of NMBDs can lead to a patient who is conscious and aware but unable to move. The anesthesia provider monitors neuromuscular blockade with a peripheral nerve stimulator using a train-of-four (TOF) technique. A patient with two or three out of four twitches is typically relaxed enough for most surgical procedures, but the neuromuscular blockade is not so deep that anesthetic reversal at the end of the procedure is prolonged.

As part of a balanced technique, opioids are administered to reduce the sympathetic response to surgical stimulus. The use of opioids typically reduces the concentration of inhalational or IV anesthetics needed to keep the patient unresponsive and can reduce some of the cardiac depressant effects seen with these

agents. Opioids also provide postoperative analgesia. However, opioids have significant postoperative side effects such as excessive sedation, respiratory depression, nausea, vomiting, urinary retention, and constipation.

In addition to opioids or increasing the concentration of anesthetic agents, the sympathetic response to surgical stimulation can also be completely blocked or partially blocked by neuraxial anesthesia, peripheral nerve blockade, local anesthesia infiltration, or sympathetic blocking agents. The use of intraoperative alpha- and/or beta-blocking agents to blunt the sympathetic response can lessen dosing of intraoperative opioids. Use of less intraoperative opioids may improve postoperative pain control and reduce some of the undesired side effects of opioid medications.

The ADS contains the ventilator control and display panel shown in **FIGURE 3.5**. During GA, all ventilation parameters are set from this panel, including inspiratory oxygen concentration, mode of ventilation, tidal volumes, respiratory rate, positive end-expiratory pressure (PEEP), inspiratory pressure, and peak airway pressure. Additionally, all alarms are set on this panel such as for tidal volumes below a threshold, or peak airway pressure greater than desired. This is reviewed constantly during the case but especially after interventions are made such as peritoneal insufflation and/or placement in Trendelenburg position. Changes in compliance, variances between set tidal volume vs delivered tidal volume, and changes in peak airway pressure and $ETCO_2$ are the most critical parameters to review.

**FIGURE 3.5** Ventilator control module with respiratory parameters' display. The *gray* boxed parameters along the bottom of the screen are set by the anesthesia provider. The top tracing (*yellow*) graphically represents airway pressures, and the peak airway pressure alarm is set by the provider. The middle tracing (*green*) shows flow rates. The bottom tracing (*white*) shows the end-tidal $CO_2$ concentration. (Avance™ $CS^2$

Anesthesia Delivery System image courtesy of GE HealthCare.)

# *Emergence*

When the surgical team is approaching completion of the surgical procedure, the anesthesia provider will prepare the patient for emergence and postoperative recovery. The provider will ensure the patient is hemodynamically stable and normothermic before emergence. A hypothermic or hemodynamically unstable patient should be kept intubated and sedated to ensure adequate ventilation and comfort until his or her vital signs are stable.

Neuromuscular blockade is reversed at the end of the procedure to ensure the patient has adequate strength to maintain ventilation and upper airway tone and reflexes. Traditionally NMBDs have been reversed with anticholinesterase medications (ie, neostigmine). Anticholinesterase medications not only antagonize the NMBD at the neuromuscular junction by increasing the amount of acetylcholine available but also have cholinergic effects at other receptors leading to side effects such as bradycardia, hypotension, bronchospasm, increased salivation or respiratory secretions, increased GI motility and secretions, miosis, nausea, and vomiting. To avoid these side effects, anticholinesterase medications are combined with an anticholinergic (glycopyrrolate or atropine). When using anticholinesterase medications for the reversal, there must be evidence of some recovery from the neuromuscular blockade (2-4 of 4 twitches on TOF) to ensure the patient will be adequately reversed.

Once the appropriateness for emergence and extubation has been determined, the anesthesia provider will reduce the concentration of maintenance anesthetics. The timing of reduction of medications depends on the specific pharmacokinetic properties and the duration of administration. Context-sensitive half-life is the time to eliminate a medication based on the total duration of a continuous infusion. The fat solubility of a medication affects its context-sensitive half-life. The higher solubility of the medication or the higher fat content of the patient (ie, obesity) leads to a longer duration of

emergence, especially with longer operations (>4 hours). Delayed emergence is defined as failure of the return of consciousness within 30-60 minutes of GA. The most common causes are residual anesthetic, sedative, or analgesic medications. Other causes include drug or alcohol overdose, preoperative ingestion, hypothermia, severe metabolic derangements, hypoglycemia, and perioperative cerebrovascular accident.

The timing and removal of the ETT is the most critical step in the emergence process. **TABLE 3.11** shows the criteria for extubation. The risks of extubating too early include inadequate ventilation, airway obstruction, aspiration, and laryngospasm. If a deep extubation is performed, the patient remains deeply anesthetized and unresponsive to external stimulus when the ETT is removed. However, most patients will be extubated when they are awake and follow commands. The most dangerous time to extubate patients (highest risk of laryngospasm) is when they are neither deeply anesthetized nor fully emerged from anesthesia (stage 2 or the excitement stage). Tachycardia and hypertension may be seen prior to extubation. These can be blunted with sympathetic blocking agents such as esmolol, which is commonly used for this purpose due to its short duration of action. Once the patient is extubated, the anesthesia provider needs to ensure that the patient is adequately ventilating prior to transport to the postanesthesia care unit (PACU).

## TABLE 3.11
## Criteria for Extubation

| |
|---|
| 1. Adequate oxygenation<br>• $SpO_2 > 92\%$, $PaO_2 > 60$ mm Hg |
| 2. Adequate ventilation<br>• $ETCO_2 < 50$ mm Hg, $PaCO_2 < 60$ mm Hg<br>• TV > 5 mL/kg, RR > 7 |
| 3. Hemodynamically stabile |
| 4. Absence of neuromuscular blockade<br>• Sustained tetany with no fade, TOF ratio >0.9<br>• Sustained head lift of 5 s or hand grasp |
| 5. Neurologically intact |
| 6. Absence of significant acid-base and/or electrolytes disturbances |
| 7. Normothermia |

$SpO_2$, peripheral capillary oxygen saturation; $PaO_2$, partial $O_2$ pressure in arterial blood; $ETCO_2$, end-tidal $CO_2$; $PaCO_2$, partial $CO_2$ pressure in arterial blood; TV, tidal volume; RR, respiratory rate; TOF, train-of-four.

# *Postoperative Recovery*

On arrival to the PACU, a detailed report of the patient's history, the procedure, intraoperative events, and the postoperative plan is provided to the postoperative nursing care team. Effective communication is critical to prevent errors and harm. Minimal requirements for monitoring in the PACU include periodic assessment and documentation of HR, cardiac rhythm, BP, airway patency, $O_2$ saturation, ventilatory rate and character, and level of pain every 5 minutes for the first 15 minutes and then every 15 minutes thereafter. Every patient should have continuous pulse oximeter and a single-lead ECG. Documentation of temperature, level of consciousness, mental status, neuromuscular function, hydration status, and the degree of nausea on admission and discharge are also minimal standards.

The most common PACU complications are reviewed in **TABLE 3.12**. PONV is increased in patients following laparoscopic procedures. Additionally, female gender is a strong risk factor for development of PONV. It seems prudent to administer prophylactic antiemetics and utilize an anesthetic regimen that minimizes the incidence of PONV in laparoscopic cases. Refractory nausea and vomiting are major reasons for admission.

## TABLE 3.12
## Postanesthesia Care Unit (PACU) Complications

| |
|---|
| Myocardial ischemia |
| Hypotension |
| Respiratory acidosis |
| Aspiration |
| Urinary retention |
| Oliguria |
| Ocular injuries |
| Hearing impairment |
| Oral/pharyngeal/laryngeal injury |
| Nerve, soft tissue, and joint injuries |
| Postoperative myalgia |
| Hypothermia |
| Shivering |
| Persistent sedation |
| Emergence reactions |
| Delirium and cognitive decline |
| Postoperative nausea and vomiting |

# Regional Anesthesia

Regional anesthesia is the loss of sensation in a region of the body by the application of a local anesthetic to all the nerves supplying that region. Regional anesthesia can be central/neuraxial (ie, epidural, spinal, or caudal) or peripheral and can be used for surgical

anesthesia or postoperative analgesia. The use of regional anesthesia for surgical anesthesia can be combined with some level of sedation or GA. While sedation is typically administered, with an adequate neuraxial or peripheral anesthesia, the patient does not require sedation or may require only a minimal level of sedation in these situations.

# *Spinal Anesthesia*

Spinal anesthesia is an injection of local anesthetic with or without opioid medication into the subarachnoid space that provides complete sensory block typically below the T4 dermatome. Spinal anesthesia can be used for abdominal, urologic, pelvic, perineal, or lower extremity procedures. Typically, spinal anesthesia is a single injection that provides 2-3 hours of surgical anesthesia. The duration of anesthesia depends on the local anesthetic used, the total dose, and patient factors. Intrathecal morphine can be added to spinal anesthesia and provide prolonged (12-24 hours) postoperative analgesia, but side effects include pruritus, and nausea, and vomiting. Delayed respiratory depression is uncommon but is a well-recognized complication of intrathecal morphine. Given the potential for respiratory depression, all patients who receive spinal morphine require respiratory monitoring (hourly respiratory rate evaluations, expiratory $CO_2$ monitoring, or continuous pulse oximeter) for 24 hours following administration. The use of intrathecal morphine can reduce the need for systemic opioids, reduce the surgical stress response, and improve postoperative recovery. Given these benefits, some perioperative care plans include single-injection spinal morphine as a part of a multimodal analgesic regimen. Complications of spinal anesthesia include hypotension, bradycardia, inadequate anesthesia, pruritus, complete or total spinal anesthesia (high blockade to the cervical level resulting in loss of diaphragm function requiring subsequent intubation), spinal hematoma, infection (meningitis or abscess formation), nerve injury, and postdural puncture headache.

# *Epidural Anesthesia*

Epidural anesthesia can be used to provide surgical anesthesia for procedures similar to those with indications for spinal anesthesia. The anesthesiologist may prefer to use an epidural technique as opposed to a spinal anesthetic in patients who are at high risk for exaggerated hypotension with spinal anesthesia (ie, aortic stenosis) or inability to tolerate hypotension (ie, significant cardiovascular or pulmonary disease). An epidural technique can also be combined with a spinal technique (combined spinal–epidural [CSE]) to allow for a longer duration of surgical anesthesia. However, most commonly epidural catheters are used for postoperative pain control. The epidural catheter is typically placed and tested preoperatively. The epidural catheter is then used to augment analgesia in combination with GA for the intraoperative anesthetic and then is left in place to continue to provide postoperative analgesia. Epidural anesthesia provides superior analgesia when compared to IV opioids and can reduce the surgical stress response, promote an earlier return of bowel function, and reduce the incidence of cardiovascular or pulmonary complications in high-risk patients.

Despite these recognized benefits, epidural anesthesia has not been shown to consistently reduce postoperative complications and does not reduce the length of hospital stay when utilized within ERAS protocols. The use of epidural anesthesia does not likely provide any benefit for patients undergoing laparoscopic or robotic procedures. For open procedures, epidural analgesia provides superior pain control in many cases, but within ERAS protocols using multimodal analgesia, the superior pain control does not necessarily translate to a reduction in complication rates or reduced hospital stay. For patients undergoing open procedures and at high risk for difficult pain control or pulmonary complications, epidural analgesia should be strongly considered. Complications of epidural anesthesia are similar to the risks associated with spinal anesthesia.

# *Peripheral Nerve Blocks*

There are many different peripheral nerve block (PNB) techniques related to the upper and lower extremities unrelated to gynecological procedures. Spinal or epidural anesthesia are commonly used to

provide anesthesia or analgesia for the abdomen, chest, or perineum; however, there are multiple PNB techniques, which can be used to provide analgesia for a narrower band or reduce the incidence of lower extremity motor blockade seen with neuraxial anesthesia. One of the most commonly used PNBs in clinical practice for gynecology-oncology procedures is the transversus abdominis plane (TAP) block. PNB can be performed using single-injection techniques, or catheters can be inserted to provide analgesia for multiple postoperative days using a continuous infusion of local anesthetics. Single-injection techniques using traditional local anesthetics (ie, ropivacaine or bupivacaine) can typically provide 8-12 hours of analgesia. Liposomal bupivacaine is a recently developed formulation of local anesthetic. The bupivacaine molecules are slowly released to provide a longer duration of action at the site of injection, typically up to 72 hours. The use of liposomal bupivacaine for postoperative analgesia is increasing and is included in many ERAS pathways. Complications related to PNBs are predominantly related to injury to surrounding structures, injury to the nerve or nerves themselves, and local anesthetic toxicity. PNBs can provide long-lasting and effective anesthesia and analgesia. They can be used to provide complete surgical anesthesia, as supplemental analgesia to GA, or for postoperative analgesia. The use of regional anesthesia for postoperative pain control can lead to superior pain relief compared to systemic analgesics as well as reduce systemic analgesic side effects, particularly opioid-related side effects.

# FLUID MANAGEMENT AND BLOOD COMPONENT THERAPY

Intravascular fluid status is estimated using patient history, vital signs, physical examination, laboratory values, urine output, and invasive hemodynamic monitoring should the clinical scenario require this. These are all indirect measurements, and multiple measurements should be taken into consideration when making clinical decisions. Unfortunately, anesthetic medications and the

neuroendocrine stress response to surgical procedures alter many of the signs and symptoms intraoperatively and in the immediate postoperative period making these variables less reliable. Intraoperatively, anesthesia providers will rely mainly on urinary flow rate, BP changes in response to positive pressure ventilation, vasodilation from anesthetic medications, and vasopressors, and acid-base status to determine fluid status.

## Perioperative Fluid Administration

A simple approach to fluid replacement is to replace insensible losses with a similar fluid to the one lost. There is continued controversy as to whether colloid or crystalloid is the best fluid to use for resuscitation. Crystalloids are salt solutions with or without glucose. Crystalloids that are used for resuscitation purposes are isotonic and designed to mimic the body's electrolyte composition (normal saline, lactated Ringer's). However, they are also hypoosmotic. Therefore, when administered, there is rapid equilibration with the extravascular fluid compartment, and only one-third of the volume of crystalloid fluid administered remains intravascular. Colloid solutions contain high molecular weight substances such as protein or starch molecules, are used to maintain osmotic pressure, and predominantly remain intravascular. Providers who support the use of colloids for resuscitation argue that colloids are more efficient (smaller volumes are needed) to restore intravascular volume and cardiac output. Supporters of crystalloids maintain that crystalloids, when given in sufficient amounts, are just as effective as colloids in restoring intravascular volume. Replacing intravascular volume with crystalloid solutions takes three to four times more volume compared to colloid. Severe intravascular deficits are more rapidly corrected using colloid solutions. The rapid administration of large amounts of crystalloid solutions (>4-5 L) is more frequently associated with tissue edema compared to colloid solutions.

Components of perioperative fluid therapy include replacing normal losses, replacing preexisting fluid deficits, and replacement of surgical wound and blood loss. **TABLE 3.13** shows the different fluid

components and methods for determining the volume needed for replacement.

## TABLE 3.13
## Fluid Maintenance, Deficits, and Losses

| | TYPES OF VOLUME LOSS | REPLACEMENT METHODS |
|---|---|---|
| Normal maintenance requirements | Urine formation, GI secretions, sweating, insensible losses from the skin and lungs in the absence of oral intake | First 10 kg, add 4 mL/kg/h<br>Second 10 kg, add 2 mL/kg/h<br>For each kg above 20 kg, add 1 mL/kg/h |
| Preexisting deficits | Prolonged fasting; preoperative bleeding, vomiting, diarrhea, or diuresis; fluid sequestration by trauma, infection, or ascites; insensible losses from hyperventilation, fever, and sweating | Fasting maintenance can be calculated using the above formula although this typically overestimates the deficit<br>Other losses may be difficult to quantify |
| Surgical fluid losses | Blood loss | Blood loss is quantified using different methods and is replaced in 3:1 or 1:1 ratio for crystalloid or colloid solutions, respectively |
| | Evaporative losses; internal redistribution (third-spacing) | Based on tissue trauma:<br>Minimal, 0-2 mL/kg/h<br>Moderate, 2-4 mL/kg/h<br>Severe, 4-8 mL/kg/h |

GI, gastrointestinal.

# Managing Blood Loss

Assessment of intraoperative blood loss is challenging. Anesthesia providers, as well as surgical teams, tend to underestimate blood loss; however, inaccuracies occur due to the challenges of visually estimating blood loss. Measuring the total volume in surgical suction canisters and subtracting nonblood fluids such as irrigation fluids or ascites is typically the first step to determining blood loss. The remainder of blood loss is evaluated by the visual estimation of blood on drapes, lap pads, and the floor. A fully saturated 4 × 4 gauze pad holds 10 mL of blood, and a fully saturated lap pad holds 100-150 mL of blood. Weighing sponges and laps can improve the accuracy of blood loss estimation; however, in the operative setting, this method is typically reserved for pediatric patients. Following serial hematocrits reflect the ratio of red blood cells to plasma but will not necessarily accurately reflect acute blood loss.

Blood transfusion is often necessary for surgical patients however, transfusion of blood products is not without risk. The risks and benefits of each individual unit of blood products must be

considered when deciding whether to transfuse a patient. The clinical question of the hemoglobin threshold at which transfusion should occur is a widely discussed and reviewed topic. The historical value of 10 g/dL has been abandoned. Several large, well-designed studies have shown that patient morbidity and mortality do not increase until hemoglobin values fall below 7 g/dL, and transfusions for higher values may be hazardous to patients and lead to worse outcomes. The threshold for patients with a history of significant cardiovascular disease remains undetermined, but these patients may benefit from transfusions at higher threshold values. The ASA Practices Guidelines for Perioperative Blood Management state that a red cell blood transfusion is almost never indicated when the hemoglobin concentration is above 10 g/dL and almost always indicated when the hemoglobin concentration is below 6 g/dL. "The determination of whether hemoglobin concentrations between 6 and 10 g/dL justify or require red blood cell transfusion should be based on potential or actual ongoing bleeding (rate and magnitude), intravascular volume status, signs of end-organ ischemia, and adequacy of cardiopulmonary reserve."

Given the hazards of blood transfusion, various blood conservation techniques exist. **TABLE 3.14** shows blood conservation techniques. **e-TABLE 3.2** **reviews complications of blood transfusion.** Conservation approaches can be useful when high blood loss is anticipated or in patients who refuse to accept blood products for religious reasons (eg, Jehovah's Witnesses). All patients undergoing surgical procedures with the risk of high blood loss (eg, myomectomy) may benefit from the use of antifibrinolytic agents such as tranexamic acid, which has been shown to reduce blood loss and the need for transfusion in multiple surgical populations.

## TABLE 3.14
## Blood Conservation Techniques

| TECHNIQUE | COMMENTS |
|---|---|
| Preoperative autologous donation | Increased overall transfusion requirement; lower preoperative hemoglobin |
| Acute normovolemic hemodilution | Limited benefit; dilution of clotting factors and platelets |
| Intraoperative blood salvage | Cost-effective, low risk |
| Postoperative blood salvage | Can be effective for certain surgical populations (orthopedic surgery) |
| Stimulants of erythropoiesis | Erythropoietin, vitamin $B_{12}$, folic acid |
| Prohemostatic agents | Vitamin K, desmopressin, antifibrinolytics (aminocaproic acid, tranexamic acid), or factor concentrates |

## e-TABLE 3.2
## Complications of Blood Transfusion

*Infectious Complications*

- Viral Infections
  - HIV
  - Hepatitis C
  - Hepatitis B
  - West Nile virus
  - Cytomegalovirus
  - Human T-cell lymphotropic virus
- Emerging Infections
  - Chagas and malaria
  - Creutzfeldt-Jakob
  - Parvovirus
  - Dengue virus and *Babesia* species
- Bacterial Contamination
  - Increased risk with platelets

*Noninfectious Complications*

- Febrile nonhemolytic transfusion reaction
- Minor allergic reactions (urticarial, flushing)
- Anaphylactic/anaphylactoid reactions
- Acute hemolytic transfusion reaction
- Delayed hemolytic transfusion reaction
- Alloimmunization
- Transfusion-related acute lung injury (TRALI)
- Graft vs host disease
- Posttransfusion purpura
- Transfusion-related immunomodulation (TRIM)
- Transfusion-associated cardiovascular overload (TACO)
- Hyperkalemia
- Citrate toxicity
- Hypothermia
- Iron overload

# SPECIAL CONSIDERATIONS FOR LAPAROSCOPIC OR ROBOTIC PROCEDURES

## Positioning

The steep Trendelenburg position desired for many laparoscopic and robotic pelvic procedures creates several challenges. There are the physical aspects of positioning and the physiologic implications of maintaining steep Trendelenburg for several hours, which are accentuated in morbidly obese patients. Physical changes such as facial, laryngeal, and conjunctival edema may occur with longer procedures. Even before the creation of a pneumoperitoneum, it is possible for the carina to shift cephalad resulting in endobronchial intubation. This situation may be more likely after insufflation of $CO_2$. Patient movement on the OR bed is possible, and this may lead to peripheral nerve injuries, most commonly involving the brachial plexus. A variety of positioning modifications have been introduced to reduce patient movement and nerve injury, but frequent checking of the patient position and padding is necessary.

The physiologic changes resulting from the Trendelenburg position affect multiple organ systems. Intraocular pressure (IOP) may increase and correlate with the duration of surgery. Functional residual capacity may decrease. Stroke volume and mean arterial pressure increase, which may lead to a decrease in HR. Central venous pressure increases. Intracranial pressure has been shown to increase in this position as well. Most of the changes related to the position are generally well tolerated and resolve upon returning to the supine position. Facial and laryngeal edema may take longer to resolve. A practice tilt, commonly called a “tilt test,” to the maximal Trendelenburg position is recommended prior to docking the robot. This allows the team to confirm that the patient is adequately secured to the OR table and is an estimate that the patient will tolerate Trendelenburg position. Preoperative testing of

Trendelenburg allows estimation of determine baseline ventilatory settings for obese patients.

## Changes Related to $CO_2$ Insufflation

The pneumoperitoneum resulting from $CO_2$ insufflation in minimally invasive procedures is associated with changes in a variety of organ systems (**TABLE 3.15**). These changes resolve following the release of the pneumoperitoneum and are well tolerated by most patients. Carbon dioxide is blood soluble such that accumulation in the blood leads to an increase in arterial $CO_2$. This leads to a decrease in pH, which resolves upon release of the pneumoperitoneum. The duration of surgery does not appear to influence the degree of hypercarbia but may be greater with pelvic surgery compared to intraperitoneal procedures. The arterial to $ETCO_2$ gradient may remain stable or increase during insufflation, and the increase may be significantly higher in patients with preexisting respiratory disease and older age. Functional residual capacity decreases as well as lung compliance, and ventilation/perfusion ratios may be altered. As the diaphragm is pushed cephalad, there is an increase in small airway closure and the potential for atelectasis. Steep Trendelenburg positioning may accentuate these changes leading to unfavorable abnormalities in gas exchange.

### TABLE 3.15 Physiologic Changes With Laparoscopy/Insufflation

| |
|---|
| Increased systemic vascular resistance and blood pressure |
| Heart rate changes<br>• Bradycardia: insufflation, vagal response<br>• Tachycardia: increase in sympathetic nervous system output |
| Variable (minimal) changes to cardiac output |
| Decreased functional residual capacity |
| Increased ventilation-perfusion mismatch |
| Cephalad carinal shift and diaphragm positioning |
| Increased arterial end-tidal $CO_2$ gradient |
| Increased cerebral blood flow and intracranial pressure |
| Decreased splanchnic and hepatic blood flow |
| Decreased renal perfusion and urine output |

Cardiovascularly, there is an increase in sympathetic nervous system output that leads to an increase in systemic vascular resistance and mean arterial pressure. Likely, this is a result of increased arterial $CO_2$ and other factors leading to catecholamine release. While cardiovascular system stability is usually maintained in healthy patients, there are many reports of decompensation in patients with significant comorbidities or hypovolemia. Morbid obesity is not known to accentuate the cardiovascular system changes.

## Optimizing Ventilation for Laparoscopic and Robotic Surgery

Maintaining normal oxygenation and respiratory system parameters during steep Trendelenburg and pneumoperitoneum can be difficult

or impossible in some patients. Patients with underlying pulmonary disease or morbidly obese patients typically present ventilatory challenges. Positive pressure ventilation modes utilized are either volume-controlled ventilation (VCV) or pressure-controlled ventilation (PCV). VCV is the most common perioperative technique, but PCV is usually recommended for laparoscopic surgery. In VCV mode, peak airway pressures can increase to potentially harmful levels in an attempt to reach a target tidal volume when compliance decreases as occurs during laparoscopy. However, in PCV mode, the target inspiratory pressure profile achieved may not deliver adequate tidal volumes. Currently accepted intraoperative ventilation strategy suggests the optimal tidal volume to be 6-8 mL/kg. Standard tidal volume targets are 5-8 mL/kg lean body weight, but during laparoscopy in steep Trendelenburg positioning, lower values may be acceptable for a short duration (3 mL/kg). Peak pressures should be kept under 40 cm $H_2O$, with plateau pressures of <35 cm $H_2O$. When VCV is used during head-down position with pneumoperitoneum, it is not uncommon to have peak inspiratory pressures (PIP) increase to over 40 cm $H_2O$. During PCV, peak airway pressures were shown to be lower, while the mean airway pressure was either the same or higher when compared to VCV. The higher mean airway pressure is helpful for preventing atelectasis and promoting ventilation-perfusion matching while the decrease in PIP is protective against barotrauma. Regardless of the ventilation strategy employed, accepting permissive hypercapnia during insufflation is often necessary and usually tolerated well.

During laparoscopic and robotic gynecologic cases, it is critical to follow trends and make appropriate changes to optimize oxygenation and carbon dioxide removal. $ETCO_2$ targets are normally between 35 and 40 mm Hg, but permissive hypercapnia into the 50-60 mm Hg range may be necessary for short periods. Adding PEEP has also been shown to improve oxygenation during laparoscopy and should be applied. PEEP levels should be at least 4 cm $H_2O$, but 10 cm $H_2O$ of PEEP is optimal as long as peak airway pressures allow for higher PEEP values. Additionally recruiting maneuvers (application of 40 cm $H_2O$ for 15-40 seconds) can be applied to most

patients and may help with gas exchange when done once or multiple times. The I:E ratio refers to the ratio of inspiratory time to expiratory time and is initially set at 1:2, but experimentation with shorter ratios (1:1) and even reverse ratio ventilation (I:E < 1) may be useful to further optimize oxygenation. Conversely, patients with obstructive lung disease may require lower I:E ratios (longer expiratory times) of 1:2.5 or 1:3 to allow for complete expiration and prevent breath stacking.

There are some patients in whom deploying these maneuvers to ensure adequate oxygenation and ventilation is unsuccessful. Patients with severe respiratory disease, elevated ICP, or elevated IOP may require open surgical procedures and benefit from combined epidural analgesia and GA (utilizing lower airway pressures). An anesthesiologist should evaluate patients with these issues in a preoperative consult clinic.

# Perioperative Complications

Anesthetic perioperative complications associated with robotic gynecological procedures are not increased compared to open procedures. Most complications are related to positioning and peritoneal insufflation (**TABLE 3.16**). Awareness of potential severe cardiorespiratory compromise is critical in the perioperative period. Cardiovascular issues include dysrhythmias, gas embolism, respiratory acidosis, capnothorax ($CO_2$ pneumothorax), and capnomediastinum. Venous gas embolism from $CO_2$ is suspected when hypoxemia, hypotension, arrhythmia, and a decrease in $ETCO_2$ (hypoperfusion) occur during insufflation. $CO_2$ rapidly diffuses, so hyperventilation and release of the pneumoperitoneum are the effective treatment steps for this situation. If those maneuvers do not restore stable cardiopulmonary function, then more aggressive cardiopulmonary resuscitation measures should be initiated without delay. The head-down position can usually be maintained.

## TABLE 3.16
## Perioperative Complications of Laparoscopic and Robotic Procedures

| |
|---|
| Cardiovascular compromise/collapse<br>• $CO_2$ embolism<br>• Capnothorax, capnomediastinum, capnopericardium<br>• Arrhythmias<br>• High insufflation pressure<br>• Severe respiratory acidosis |
| Visual disturbances |
| Peripheral nerve injury |
| Subcutaneous emphysema |
| Hypothermia |
| Airway edema |
| Postoperative nausea and vomiting |

Capnothorax is a rare complication of laparoscopic procedures and is usually associated with surgery near the diaphragm. $CO_2$ entry into the pleural space is associated with a diaphragmatic defect but could also occur secondary to the mechanisms that cause tension pneumothorax to occur (ruptured lung bulla). Subcutaneous emphysema may be present in addition to unequal chest expansion and cardiovascular instability. Although a chest x-ray would confirm the diagnosis, treatment should be initiated without delay. The initial step is release of the pneumoperitoneum, and this may resolve the problem without the need for more aggressive treatments. In severe cases, emergency evacuation of gas can be accomplished by needle thoracostomy. Less common complications include capnomediastinum and capnopericardium, which occur when

insufflated $CO_2$ accumulates in the mediastinum and pericardium. Cardiovascular issues may be severe, and the diagnosis is made on CXR. Because of the enhanced solubility of $CO_2$, many of the potential problems related to errant gas accumulation will resolve quickly after release of pneumoperitoneum without major sequelae.

Subcutaneous emphysema is noted by crepitus occurring secondary to extraperitoneal insufflation of $CO_2$. It can be seen in the abdomen, chest, groin, and neck and is usually not associated with any additional morbidity. Occasionally, it may be associated with hypercarbia, and diagnosing respiratory acidosis by arterial blood gas would be confirmative. If severe subcutaneous emphysema is noted postoperatively in cephalad areas such as the neck and face, it is possible that gas may have tracked into the thoracic cavity and/or mediastinum. In this scenario, ordering a CXR is indicated if there is evidence of cardiorespiratory dysfunction.

Hypothermia during laparoscopic pelvic surgery has an incidence similar to that of open procedures. It is most likely due to the insufflation of nonwarmed and dry $CO_2$ into a large surface area environment. Convection currents allow for heat transfer from the patient, and the duration of the procedure is a factor for this. Intraoperative temperature monitoring is an important component of anesthetic monitoring, and active patient warming devices should be used if needed (ie, warm air convection blankets and IV fluid warmers).

Ocular complications have been reported after laparoscopic surgery. The most common complication is corneal abrasion, but the most severe one is perioperative visual loss (POVL), which can be devastating and lead to permanent loss of vision. It has been reported after spine surgery and laparoscopic procedures. IOP increases in the Trendelenburg position, which is time dependent. Increases in IOP reduce optic nerve blood flow via vessel compression. Chronic glaucoma may be a risk factor since IOP is often increased in these patients. In patients who are deemed at higher risk for POVL, avoidance of hypotension, use of colloids, and maintenance of anesthesia with propofol (compared to inhalation agents) can reduce this risk. Some inhalational agents are associated with greater risk of development of IOP. During prolonged

laparoscopic cases in the Trendelenburg position, some authors have specific recommendations such as intraoperative IOP monitoring and topical eye treatments if IOP is elevated. It is also important during robotic surgery to prevent direct ocular injury from control arms and other moving parts.

# ENHANCED RECOVERY METHODS

ERAS is the acronym for Enhanced Recovery after Surgery. The ERAS concept was established by a group of surgeons from Northern Europe who formed a research group to explore evidence-based care pathways for patients undergoing colonic resections. Between 2001 when the collaborative group was first created and 2005, the group showed there was a large discrepancy between current practices and the best practices based on available evidence. In 2005, the group published their first evidence-based consensus protocol for patients undergoing colonic surgery. In the group's initial publication, they emphasized that the factors requiring hospitalization—IV opioid medications, IV fluids, and bed rest—often delay the return of function and prolong recovery. It is accepted that a stress response to surgery is inevitable. Conventional postoperative care has focused on prolonged rest for the patient and his or her GI tract to allow recovery from the surgical stress response. The ERAS concepts challenge conventional methods and focus on the appropriate application of modern anesthetics, analgesics, and metabolic support as well as early mobilization and oral intake to reduce the stress response to surgery and hasten recovery. Systematic implementation of ERAS pathways has resulted in a reduced length of postoperative hospital stays by 30%-50%, a decrease in complication rates by as much as 50%, lower readmission rates, and cost savings. The initial ERAS protocols and studies were in colorectal surgery; however, the principles are now applied in many different institutions worldwide and surgical disciplines including gynecology and gynecologic oncology. The initial ERAS Gynecologic/Oncology guidelines were published in 2016 and were updated in 2019.

# KEY POINTS

- A preoperative anesthetic consultation presents many opportunities to influence and optimize perioperative care. An anesthesiologist must evaluate the surgical patient for factors that increase the patient's risk for an adverse outcome. This is typically performed days or weeks prior to surgery in a preoperative consultation clinic.
- The components of the anesthetic state include unconsciousness, amnesia, analgesia, immobility, and attenuation of autonomic responses to noxious stimulation. Every anesthetic does not require complete deprivation of all components. However, the goals of an individual anesthetic are to ensure patient comfort and safety while providing the surgical teams with the patient condition needed to complete the necessary or desired procedure.
- Induction and emergence are the two most critical times of an anesthetic. Timing and removal of the ETT is the most critical step in the emergence process. The most dangerous time to extubate a patient is when the patient is neither deeply anesthetized nor fully emerged from anesthesia.
- The incidence of PONV is high in female patients undergoing laparoscopic procedures. It is prudent to administer prophylactic antiemetics, utilize an anesthetic regimen that minimizes the incidence of PONV, and aggressively treat PONV in the PACU. Refractory nausea and vomiting are major reasons for admitting patients who would otherwise be discharged after outpatient surgery.
- Epidural anesthesia can provide excellent and superior pain control; however, the routine use of epidural anesthesia has not been shown to consistently reduce postoperative complications or the length of hospital stay within ERAS protocols. For patients undergoing open procedures and at high risk for difficult pain control or pulmonary complications, epidural analgesia should be strongly considered.

- The steep Trendelenburg position and peritoneal insufflation frequently increase blood pressure and central venous pressure. Overall, there are no significant changes in cardiac function. At completion of the case, there is typically a rapid return to baseline cardiovascular parameters.
- Accumulation of $CO_2$ during laparoscopic cases is due to absorption of gas from the peritoneum as well as potential decreases in ventilation due to positioning and body habitus. Resolution usually occurs rapidly with release of pneumoperitoneum. In the case of cardiorespiratory instability, there should be increased suspicion for gas in the pericardium, mediastinum, or pleural cavity.

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# CHAPTER 4

# RADIOLOGY PRIMER FOR THE GYNECOLOGIST

Ersan Altun and Kristen Olinger

**Essentials of Imaging**
Ultrasound
Computer Tomography
Magnetic Resonance Imaging
Positron Emission Tomography
Radiographs
**General Imaging in Gynecology**
**Imaging for Developmental Disorders**
**Imaging for Acute Pelvic Pain and Abnormal Uterine Bleeding**
Cyst Rupture and Hemorrhagic Cysts
Ovarian Torsion and Tubal Torsion
Pelvic Inflammatory Disease and Tuboovarian Abscess
Endometrial Polyps
Endometriosis and Adenomyosis
**Imaging Findings for Common Benign Neoplastic Disease Processes**
Fibroids
Dermoid Cysts

**Imaging Findings of Common Cystic Lesions of Lower Genitourinary Tract**

Urethral Diverticulum

Vulvar and Vaginal Cysts

**Imaging Findings for Gynecologic Cancers**

Cervical Cancer

Endometrial and Uterine Cancers

Vaginal and Vulvar Cancer

Ovarian Cancer

**O-RADS US and O-RADS MRI Classification System for Adnexal Masses**

Risk Stratification Based on Ultrasound

Risk Stratification Based on MRI

**Imaging for Complications of Pelvic Surgery**

Imaging is critical for the detection, characterization, and diagnosis of gynecologic disorders. Additionally, imaging plays a significant role in clinical decision-making, staging, treatment planning including presurgical planning, assessment of treatment response, and postsurgical complications. Multiple imaging modalities are used for these purposes depending on the diagnosis and extent of disease. In this chapter, a general overview of commonly used imaging modalities as well as characteristic imaging findings of common disease processes is discussed.

# ESSENTIALS OF IMAGING

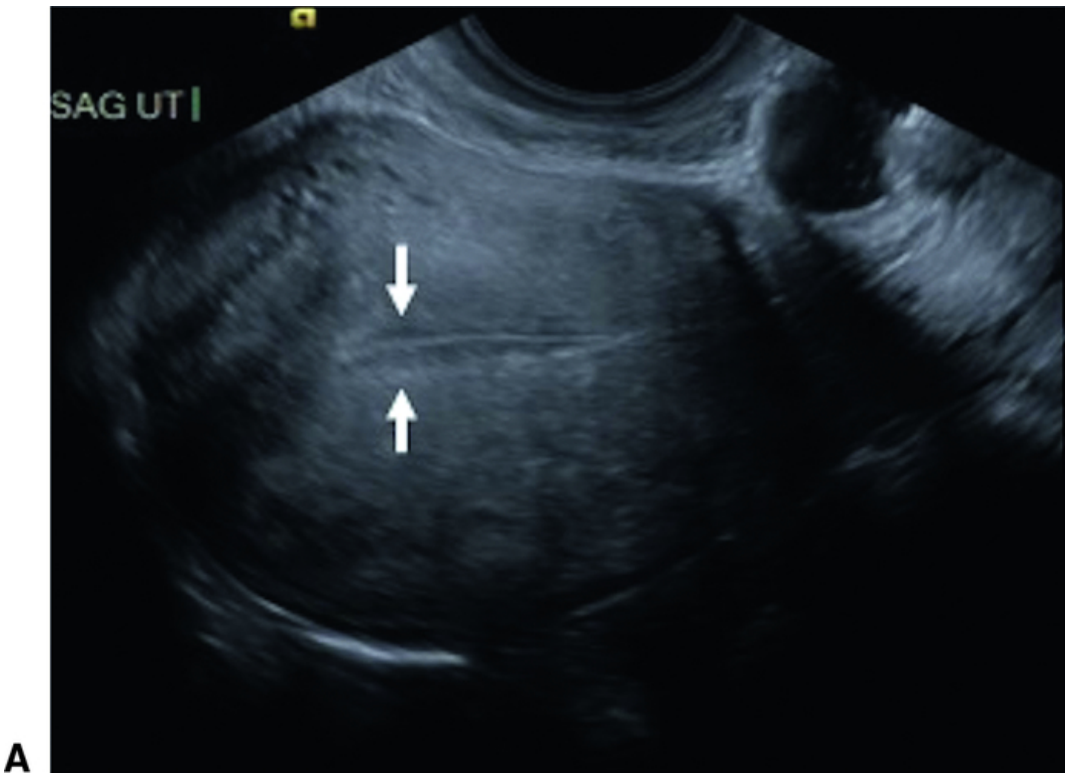
## Ultrasound

Ultrasound (US) imaging uses a transducer to produce sound waves to provide images of soft tissues. It has good soft tissue contrast with

high spatial resolution and does not use ionizing radiation and thus has no harmful radiation side effects. A typical transvaginal ultrasound takes ~30 minutes and includes both long and short axis views of the uterus, cervix, and ovaries.

US can be performed endovaginally with an empty bladder or transabdominally with a full bladder. Sagittal and transverse images should be acquired consistently with color and spectral Doppler evaluation of the ovaries and uterus (particularly if there is any relevant pathology in the uterus). Saline-infused sonohysterography (SIS) assesses intracavitary lesions, such as polyps, submucosal and pedunculated fibroids, and can define the anatomy of the endometrial cavity. SIS is performed by inserting a small caliber catheter into the uterine cavity followed by infusion of 5-30 cc saline. Transperineal and translabial US are performed to assess more superficial pathology such as mid and distal vaginal, urethral, or vulvar lesions. Transrectal US is available to evaluate vaginal lesions or lesions adjacent to the vagina.

There are three levels of ultrasound. The basic level, B-mode or gray scale uses the standard brightness mode. The second level, color Doppler, superimposes blood flow onto the gray-scale image. The third level, spectral Doppler, can provide information on the waveform through targeted interrogation of a vessel. The addition of Doppler images to the standard pelvic ultrasound can confirm the presence or absence of blood flow within a structure and is useful for the evaluation of suspected ovarian torsion and malignancy workup and to help differentiate solid tissue from complex fluid or hematoma (**FIG. 4.1**).

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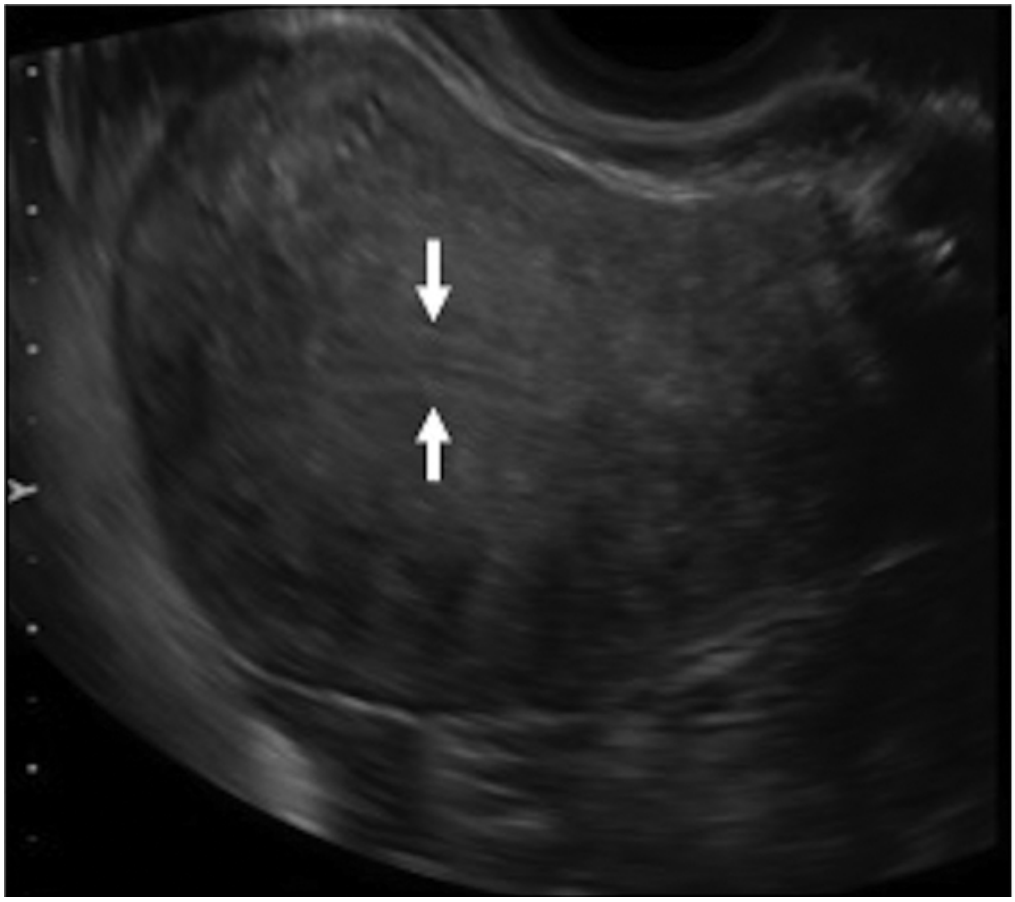


B

**FIGURE 4.1** Normal sonographic appearance of the endometrial stripe on the midline sagittal images **(A, B)**. **A.** Thin, echogenic endometrium (*arrows*) seen in the menstrual phase (1-4 days). **B.** Trilaminar appearance of the endometrium (*arrows*) in the late proliferative phase (13-16 days).

## Computer Tomography

Computer tomography (CT) utilizes ionizing radiation to acquire volumetric imaging data in the transverse plane by employing x-ray tubes and detectors, which are usually rotating around the patient during the examination. These data can be reconstructed into various image planes with variable slice thicknesses however, a typical CT usually is interpreted with 3-mm slice thickness on transverse, coronal, and sagittal reconstruction planes. CT is usually a very fast imaging technique, and the actual time required for a routine body CT takes <30 seconds; usually two short breath-holds are sufficient for CT scan of the chest, abdomen, and pelvis. CT can easily be performed in the acute care setting and in patients who have difficulty holding their breath. Patients find CT imaging more tolerable and less claustrophobic compared to magnetic resonance imaging (MRI).

IV contrast, which is iodine-based contrast, is recommended when evaluating infectious, inflammatory, or neoplastic processes as well as for vascular imaging. IV contrast improves the assessment of the pelvic organs since the soft tissue resolution is significantly low with noncontrast CT. The use of oral contrast is helpful for more complex cases to differentiate bowel loops from the adnexal pathology. A routine CT abdomen and pelvis is performed in the venous phase around 70-90 seconds after IV contrast administration. IV contrast used for CT imaging is a low-osmolar or iso-osmolar iodinated contrast agent and can also be used as oral

contrast in very diluted forms. Special significantly diluted forms of barium can also be used as oral contrast agents.

IV contrast should be used with caution in patients with prior contrast reactions or compromised renal function. If there is a history of a severe reaction such as anaphylaxis, IV and oral contrast should be avoided. If there is a history of moderate reactions, premedication with steroid use is recommended for future examinations (**TABLE 4.1**) in accordance with 2021 American College of Radiology guidelines. IV contrast should be cautiously used if there is poor renal function, acute kidney failure, and chronic kidney disease (CKD) or if residual renal function is particularly critical to preserve. Patients who have end-stage renal disease without any concern for residual renal function or patients undergoing hemodialysis can have IV contrast-enhanced CT studies. Additionally, iodinated contrast agents should be cautiously used in patients who use metformin since metformin has the potential to cause lactic acidosis. Therefore, metformin should be discontinued prior to the examination and can be resumed 48 hours later.

## TABLE 4.1
## Regimen for Patients With Contrast Allergy

| |
|---|
| Prednisone 50 mg po 13, 7, and 1 h before IV contrast administration<br>With or without Benadryl 50 mg po 1 h before IV contrast administration<br>OR<br>Hydrocortisone 200 mg IV 5 h and 1 h<br>and Benadryl 50 mg IV 1 h before IV contrast administration |

Data from American College of Radiology. *ACR Manual on Contrast Media*. 2021:5-13. https://www.acr.org/-/media/ACR/Files/Clinical-Resources/Contrast_Media.pdf

CT urogram provides enhanced evaluation of the kidneys, ureters, and bladder and has largely replaced the traditional intravenous urography (IVU). Initial noncontrast images are obtained and then additional images are obtained after administration of IV contrast.

Images are then captured in the nephrogenic phase (75 seconds postinjection) and excretory phase (5 minutes postinjection). The excretory phase is timed to optimize the opacification of the ureters with contrast, and therefore, this study can be helpful for assessment of the ureters for surgical planning and to evaluate for postoperative complications such as ureteral injury or leak. CT cystogram is preferred for the evaluation of bladder abnormalities, injury, or bladder integrity after surgical repair. For this study, iodinated contrast diluted in saline is instilled into the bladder utilizing a Foley catheter and typically no intravenous contrast is needed.

Chest CT is usually performed for assessment of acute or incidental lung pathologies such as aspiration pneumonia or for surveillance of metastatic disease. For these purposes, a noncontrast chest CT usually is sufficient. However, chest CT with iodinated contrast is ordered for more complex cases requiring the assessment of mediastinum, pleural space, and vessels such as in cancer cases.

CT angiography is a specific study for the assessment of arterial vasculature and pulmonary arteries. It is performed with higher iodinated contrast volume and/or iodine concentration and faster injection rates to be able to demonstrate arterial vasculature with high spatial resolution. CT angiography is commonly used for the assessment of pulmonary embolism and can also be used for the assessment of arterial vasculature for suspected acute or chronic vascular pathologies or surgical planning. CT venography could also be specifically performed for the assessment of venous system in the upper and lower extremities with the use of delayed phase; however, venous system of the chest and abdomen/pelvis is usually sufficiently evaluated on standard single-phase contrast-enhanced CT, which is usually performed in the venous phase. CT of the head is performed for the assessment of postoperative complications and is performed without IV iodinated contrast.

Hounsfield unit (HU) is a quantitative measurement of density on CT images and based on absorption and attenuation of radiation by the tissues. HU increases if the density of tissue increases. Arbitrarily, the HU of fluid is determined as 0. Air demonstrates −1000 HU, while the bone shows 1000 HU due to its high density.

Typically, blood products show 50-90 HU, and soft tissues show 30-60 HU in the abdomen and pelvis.

# Magnetic Resonance Imaging

MRI is a more sophisticated and expensive technique compared to CT and utilizes a powerful magnetic field around the patient and pulses of radiofrequency to create cross-sectional images of the body. The scan times are much longer in comparison to CT imaging, lasting anywhere from 15 to 45 minutes depending on the area imaged. Patient factors such as claustrophobia due to the small size of the machine cavity, inability to perform longer breath holds, and intolerance to loud noises are important to consider, although MRI can be performed with variable levels of sedation and breathing-independent imaging techniques. Certain implanted medical devices and metal in the body such as bullets and shrapnel may impair accurate interpretation of scans or preclude obtaining a scan altogether. However, it may be possible to obtain valuable information on MRI with sequences employing metallic artifact reduction. If the patient has implanted devices including cardiac devices, stents, or foreign bodies, the case should be discussed with radiology team, and detailed information about the case should be given during the referral.

There are several benefits of MRI over CT, including the lack of exposure to ionizing radiation and higher soft tissue contrast resolution. MRI's strength lays in its excellent visualization of soft tissues and is the scan of choice for the assessment of pelvic cancers, liver lesions, bone, and brain metastases. T1- and T2-weighted sequences are basic pulse sequences and rely on the principle that specific tissue types will exhibit different longitudinal and transverse relaxation times and therefore will demonstrate different levels of "brightness" on T1 and T2 sequences. For example, with simple fluid, the long longitudinal relaxation time results in a dark signal on a T1-weighted sequence and the long transverse relaxation time results in a bright signal on a T2-weighted sequence. T1 sequences provide the best contrast for paramagnetic gadolinium-based contrast agents (GBCAs). The high resolution and

small field of view T2-weighted sequences are essential for staging of gynecological malignancies due to improved spatial resolution.

While less common compared to the iodinated contrast, if there is history of severe allergic reactions or anaphylaxis, GBCAs cannot be used. If there is history of moderate allergic reactions, premedication regimens similar to those recommended for iodinated contrast allergies can be administered. Additionally, GBCAs should not be used in patients with acute renal impairment, class V CKD, or if undergoing hemodialysis. Placement of gel into the vagina is particularly important for the assessment of vaginal and cervical cancers and a combination of vaginal and rectal gel may also be helpful for the assessment of endometriosis. The use of intravenous antiperistalsis agents can improve image quality by decreasing motion artifacts from bowel contractions.

MR angiography is performed for the assessment of arterial and venous vasculature in selected cases. MRI of the brain and spine can be performed with and without GBCA. Alternative imaging approaches are summarized in **e-TABLE 4.1** if there is contraindication to the use of specific imaging techniques.

## e-TABLE 4.1
## Imaging Approaches When Contraindications to Specific Imaging Modalities Are Present

| | CT | MR | NONCONTRAST MRI OR ULTRASOUND |
|---|---|---|---|
| **Severe allergic reaction or anaphylaxis** | MR could be performed if there is history of severe allergy or anaphylaxis to iodinated contrast. | CT could be performed if there is history of severe allergy or anaphylaxis to gadolinium-based contrast. | Noncontrast MRI or CT or ultrasound could be performed if there is history of severe allergy to both types of contrast |
| **Renal impairment and dialysis** | IV contrast use is not recommended in patients with acute renal failure.<br>The risk of CIN[a] significantly increases in patients with eGFR[b] <30 mL/min/1.73 $m^2$.<br>IV contrast should be cautiously used in this patient group and periprocedural IV hydration could be helpful to decrease the risk of contrast induced nephropathy.<br>Iodinated contrast media can be used if there is no residual renal function but there will be no urographic component. | IV contrast use is not recommended in patients with acute renal failure, patients with end-stage renal disease or patients undergoing dialysis due to risk of nephrogenic systemic fibrosis and gadolinium deposition.<br>IV contrast should be cautiously used in patients with stage 4-5 chronic kidney disease not undergoing chronic dialysis.<br>Stable gadolinium agents are used in patients having eGFR <30 mL/min/1.73 $m^2$. | Noncontrast MRI or CT or ultrasound can be performed if clinical questions could be answered without the use of IV contrast. |
| **Incompatible implants or implants causing significant artifacts and image degradation** | Depending on the type of implant, MRI could be considered. | Depending on the type of implant, CT could be considered. | Ultrasound could also be considered if the artifacts are present on both MRI and CT. |
| **Pregnancy** | Noncontrast MRI or ultrasound should be performed. CT could be performed in selected cases such as in trauma. | Noncontrast MRI or ultrasound should be performed. | N/A |

CIN is contrast induced nephropathy.
eGFR estimated glomerular filtration rate.

# Positron Emission Tomography

Positron emission tomography (PET) is a nuclear medicine modality utilizing positron emitters such as 18-F fluorodeoxyglucose (FDG). Tumor imaging with FDG is based on the principle that cancer cells maintain increased glucose metabolism. Like glucose, FDG is taken up by the cancer cells through glucose transporters. The radioisotope portion of the radiotracer emits a positron (a positively charged electron), which collides with a negatively charged electron. On impact, the entire mass of the positron and electron becomes two photons. The two photons travel in opposite directions and are detected by two oppositely positioned detectors in the PET scanner, which are recorded then reconstructed into high resolution images for review. PET is rarely ordered alone, and CT is almost always added to PET for a combined PET-CT scan, which corrects the PET data for tissue attenuation and provides anatomic correlation. This

CT is not a diagnostic CT and does not require contrast. For this PET-CT, the patient undergoes a CT scan, followed by a PET scan without changing the patient position. PET-CT has been proven to increase the diagnostic accuracy compared to stand-alone PET. For gynecologic cancers, PET-CT scan includes the base of the skull through the upper thighs. There are situations where the CT portion of PET-CT can be diagnostic; if a diagnostic study is required, as part of PET-CT, intravenous and oral contrast should be ordered. Institutions will call this a different study so if a diagnostic CT is requested, this should be made clear on the order protocol. PET-MRI combinations are also available in some institutions. FDG is not nephrotoxic and can be used safely in patients with renal impairment.

FDG avidity can also be seen in benign processes such as infection and inflammation since FDG is used significantly by the inflammatory cells. This is the most common reason for false-positive findings on PET scans when ordered for cancer management. Reviewing the patient's medical history and determining the likelihood of an infectious or inflammatory process will facilitate a more accurate PET interpretation.

The CT portion of the PET-CT is performed quickly, usually in 1 minute, while the PET is performed around 20-30 minutes. However, a patient should expect to spend 2 hours in the radiology suite when time for IV injection and prep is included. Preparation for PET-CT imaging includes avoiding glucose drinks and any IV glucose, fasting for preferably 6 hours, and avoiding excessive physical activity for 24 hours before the radiology appointment. Fasting lowers blood glucose level and competition between FDG and glucose for uptake in the tumor cells. Decreased physical activity allows for less FDG muscle uptake. Blood glucose is also drawn when the patient arrives for PET-CT, and the goal is a blood glucose of not higher than 200 mg/dL. However, most facilities perform PET despite higher blood levels for practical reasons: If a diabetic patient has a blood glucose level of higher than 200 mg/dL, it is unlikely that the glucose level can be lowered in a timely fashion to obtain PET results for clinical decision-making. In the United States, most institutions perform PET despite glucose levels of higher than 200 mg/dL and assess the

quality of images. If the imaging specialist believes that because of high glucose level, the diagnostic accuracy could be reduced, a recommendation will be made to the referring physician to repeat the study after lowering the blood glucose level.

When considering that MRI is the preferred cross-sectional imaging modality in evaluation of the female reproductive tract, it is easy to see why the combination of PET and MRI has unique advantages over the use of PET-CT. These include significant reduction in the radiation exposure, which is of particular concern in a young patient, higher soft tissue contrast, and the ability to detect metabolic activity with a standard diagnostic MRI examination also employing dynamic contrast enhancement evaluation. Current literature suggests that PET/MRI performs similarly to PET-CT. However, some limitations exist including long scan times.

# Radiographs

## *Chest and Abdominal X-Ray*

The most commonly ordered radiographs are chest radiographs and abdominal radiographs. Chest radiographs preferentially should be done upright with PA (posteroanterior) and lateral projections for optimal assessment. However, chest radiographs are usually done supine with AP (anteroposterior) projection for patients who are not able to stand, which can limit the assessment for the detection of early or small volume or complex disease processes. Abdominal radiographs are usually done supine and/or upright with AP projection. Supine radiographs are better than upright radiographs for the assessment of bowel gas pattern and bowel obstruction. Upright radiographs are performed for the detection of large air-fluid layers in bowel loops, which can indicate bowel obstruction, or the detection of free air in cases of viscus perforation. If the patient is not able to be upright, left lateral decubitus radiograph is used for the detection of free air. A “3-way” abdominal series includes (1) PA chest radiograph, (2) upright or left lateral decubitus radiograph, and (3) AP supine abdominal radiograph. This series are often ordered to assess for acute causes of abdominal pain.

# GENERAL IMAGING IN GYNECOLOGY

US is the most utilized imaging technique for the assessment of the uterus and adnexa. On US imaging, the position of uterus may change secondary to the distension of the urinary bladder. Therefore, endovaginal US is performed when the bladder is empty and transabdominal ultrasonography is performed when the bladder is full. The position of uterus is described according to the angle between the longitudinal axis of cervix and that of vagina ("-version) and the angle between the longitudinal axis of the uterus and that of cervix ("-flexion"). The uterus is usually anteverted with or without some degree of anteflexion, and this position makes the endovaginal assessment easier. A retroverted uterine position with or without retroflexion can make the assessment of the uterus difficult mostly secondary to overlying adjacent bowel gas transabdominally and endovaginally.

Endometrial thickness and morphology changes with the phase of menstrual cycle. The endometrium is thin and echogenic during the menstrual phase (day 1-4) and early proliferative phase (day 5-13) showing gradual thickening up to 12 mm before the ovulation. During the late proliferative phase (day 13-16), the endometrium shows trilaminar or striated appearance on the anterior and posterior half of endometrium. Following ovulation, in the secretory phase (day 16-28), the more homogenous hyperechoic endometrium replaces the trilaminar pattern with similar thickness. The morphology of endometrium should always follow the phase of endometrial cycle, and endometrial thickness is measured on the midline sagittal plane of endovaginal ultrasound where the endometrium is widest, usually at the level of the fundus. The fluid in the endometrium should not be included in the measurement of endometrial thickness. Postmenopausal endometrium is typically atrophic and may contain trace fluid in an endometrium measuring <2 mm in thickness. The likelihood of endometrial carcinoma is very low when the endometrium measures 5 mm or less in thickness in postmenopausal women, whereas the risk significantly increases above 5 mm. Of note, the Ameriecan College of Ob/Gyn recommends a cut off of 4mm or less which has a greater than 99%

negative predictive value for endometrial cancer while other studies suggest a 5mm cutoff. In postmenopausal women without vaginal bleeding, the endometrial thickness cut-off is less well-established, and cut-off values of 8-11 mm have been suggested. In patients who take tamoxifen, an endometrial thickness >8 mm requires further assessment. The myometrium of the uterine body and fundus, and cervix show homogeneous echotexture. The endocervical canal is usually seen with trace fluid, and multiple Nabothian cysts due to mucus retention in the endocervical glands.

MRI is the best technique for the assessment of uterine anatomy. Details of the endometrium can be seen on high-resolution T2-weighted sequences. The endometrium shows high T2 signal because of its high concentration of mucin-rich glands. The junctional zone (inner myometrium) shows low T2 signal due to more dense smooth muscle and low water content, and the outer myometrium shows intermediate T2 signal due to less dense smooth muscle with larger blood vessels and greater water content. The cervix similarly demonstrates three distinct layers on MRI including endocervical canal and mucosa with high T2 signal (inner layer), predominantly fibrous stroma with low T2 signal (middle layer), and muscular layer with intermediate T2 signal muscular layer (outer layer) (**FIG. 4.2**).

**FIGURE 4.2** Normal MRI anatomy of uterus. MR image in the pelvis demonstrating the normal uterine anatomy, including high T2 signal of the endometrium (*long white arrow*), normal junctional zone (*short thick white arrow*), and outer myometrium (*asterisk*).

The endometrium shows hypoattenuation compared to myometrium on most phases of contrast enhancement on CT, and this should not be interpreted as fluid. If the endometrium can be reliably distinguished from the myometrium due to its hypoenhancement, thickness can be determined. Retroverted uterus can mimic a mass adjacent to the rectum on transverse CT images, and reformatted views should be carefully assessed. The cervix also usually shows hypoenhancement on CT compared to the remaining uterus due to large volume of fibrous tissue.

The upper limit of ovarian volume in premenopausal females is 20 mL although the mean ovarian volume is usually 5-6 mL in premenopausal period and gradually decreases in volume in postmenopausal period. The ovaries typically show less enhancement compared to the myometrium. The corpus luteum shows thick walls with intermediate to low signal on T2-weighted images on MRI.

The normal fallopian tubes are difficult to visualize at imaging and can usually be seen if they show enlargement due to inflammation, infection, or dilation due to fluid collection or pus. The round ligaments can be seen on CT and MRI and distinguished from the tubes by their anterior course extending into the inguinal internal rings. The broad ligament is difficult to see unless there is ascites, but it is better seen particularly on coronal or sagittal cross-sectional imaging planes. Uterosacral ligaments can also be distinguished on MRI extending from the uterine cervix laterally and upper vagina to coccygeus muscle, ischial spine, sacrospinous ligament at the level of S2-S4.

Uptake of FDG on PET/CT is commonly seen in ovaries unilaterally and focally in corpus luteum in the late follicular and early secretory phases of premenopausal women. Endometrial uptake is also usually seen during the ovulatory phase and menstruation. To avoid potential misinterpretations, PET/CT should be performed a week before or a few days after menses.

Normal postpartum uterus will show heterogeneous increased echogenicity, intensity or attenuation on US, MRI, and CT, respectively, compared to that of nongravid uterus. The myometrium also shows heterogeneous increased enhancement on CT and MRI.

The placental implantation site will be more heterogeneous and show increased vascularity or enhancement in the absence of abnormal postpartum bleeding. Intracavitary fluid, blood products, lochia, and gas are common findings in the postpartum period. The endometrial cavity can be dilated up to 2 cm. Gas and blood products can be seen up to 3 weeks following vaginal or cesarean delivery. Edema of the cervix and parametrial tissues, periuterine edema, small volume free fluid, and hematomas are usually present if CT is obtained.

# IMAGING FOR DEVELOPMENTAL DISORDERS

Congenital uterovaginal anomalies, or müllerian duct anomalies (MDA), are found in 1%-5% in the general population to up to 25% of women with recurrent pregnancy loss. A thorough understanding of the underlying embryology relevant to formation of the internal sexual organs is necessary to understand the imaging spectrum of MDAs. MRI is the preferred imaging modality for evaluation of MDA.

Each fetus is equipped with the two sets of ducts: the mesonephric (Wolffian) ducts form the male internal sexual organs and the paramesonephric (müllerian) ducts form the female sexual organs. The Y chromosome produces a müllerian-inhibiting factor, and in the absence of this factor, müllerian duct development is promoted. These ducts give rise to the uterus, fallopian tubes, cervix, and the upper two-thirds of the vagina. If this pathway is not promoted, resultant findings include an agenesis or hypoplasia of the upper vagina, cervix, and uterus. This is seen in the Mayer-Rokitansky-Küster-Hauser syndrome.

A unilateral ductal developmental abnormality can present radiographically as a unicornuate uterus with or without a communicating or noncommunicating rudimentary horn. By ultrasound or MRI, this appears as an oblong structure off-midline and often the rudimentary horn, if present, is difficult to visualize (**FIG. 4.3**).

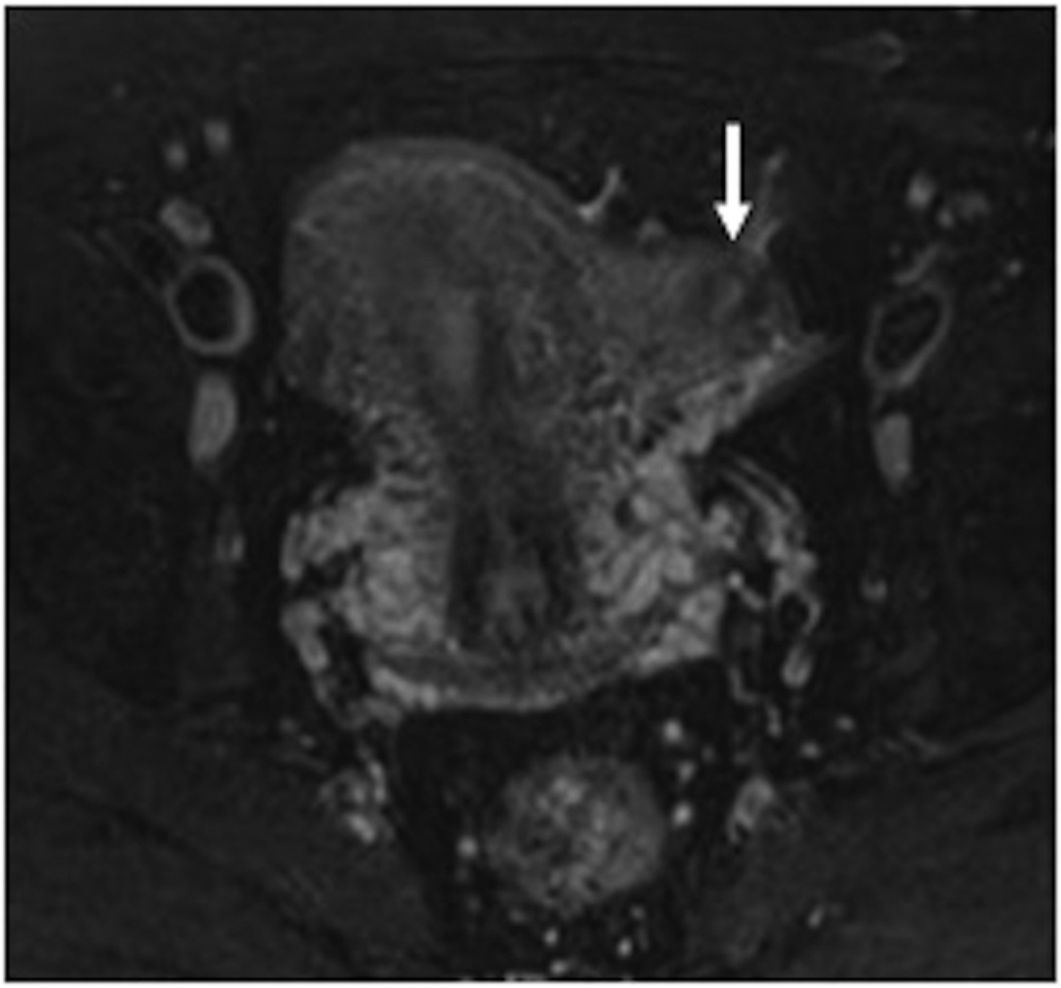
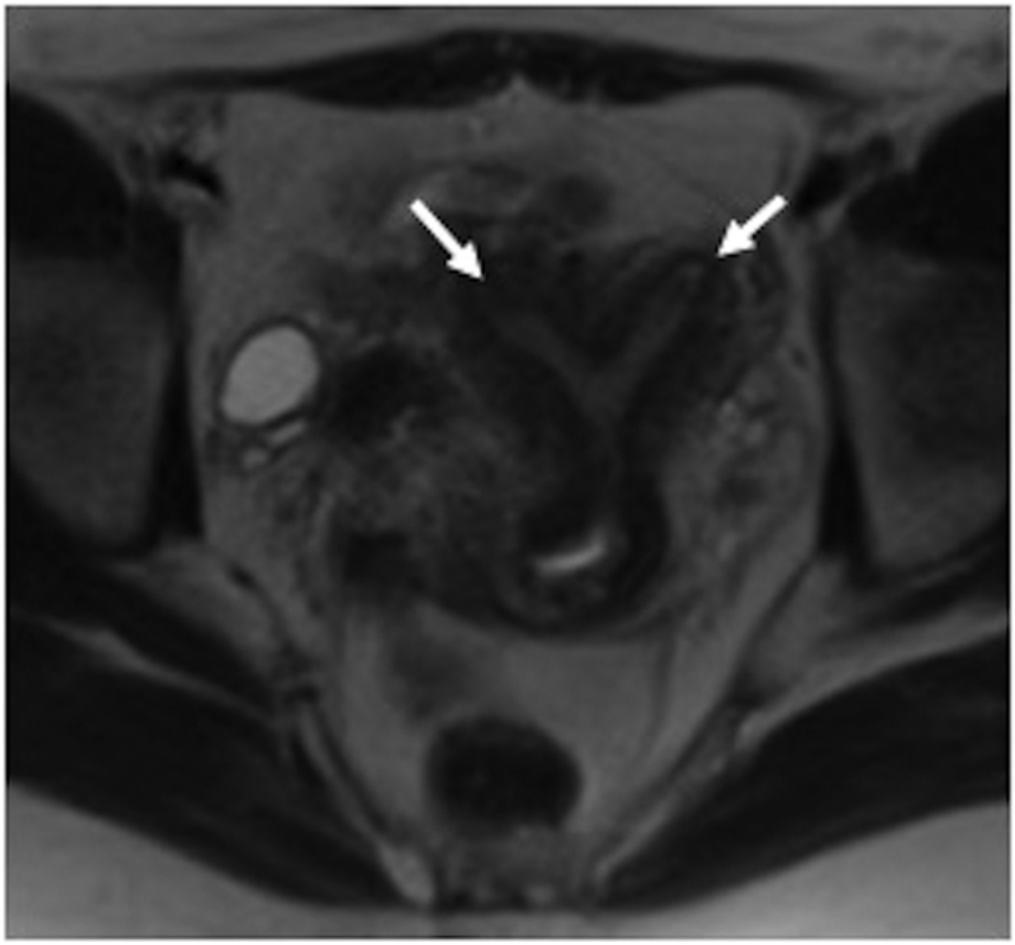


**FIGURE 4.3** Unicornuate uterus. Unilateral ductal developmental abnormality with single dominant endometrial cavity and noncommunicating left rudimentary horn on MRI (arrow).

The process of ductal growth is accompanied by a process of midline migration and fusion to form the uterovaginal primordium. During gestational weeks 9 through 12, the fused ducts undergo resorption of the uterovaginal septum. At ultrasound, the presence or absence of a fundal cleft distinguishes between the fusion and resorption anomalies, respectively.

Errors of fusion can result in a bicornuate uterus or uterine didelphys if there is partial or complete failure of müllerian duct fusion, respectively. Both will present on US and MRI as two divergent endometrial cavities; however, the cavities in didelphys are typically more widely divergent with interposed fat. Communication between the endometrial cavities may be noted in a bicornuate uterus. Two cervices can be seen in either process.

Errors of septal resorption manifest as a septate or arcuate uterine subtype. US or MRI studies of a septate uterus will demonstrate a partial or complete midline soft tissue structure with a normal convex fundal contour. This can be differentiated from a bicornuate or didelphys uterus by measuring the apex of the fundus relative to the level of the tubal ostia, which is more than 5 mm above the interostial line in the septate uterus and below or <5 mm in the fusion anomalies. In the setting of an arcuate uterus, there is near-complete resorption with only a broad, smooth inward contour deformity of the uterine fundus (**FIG. 4.4**).



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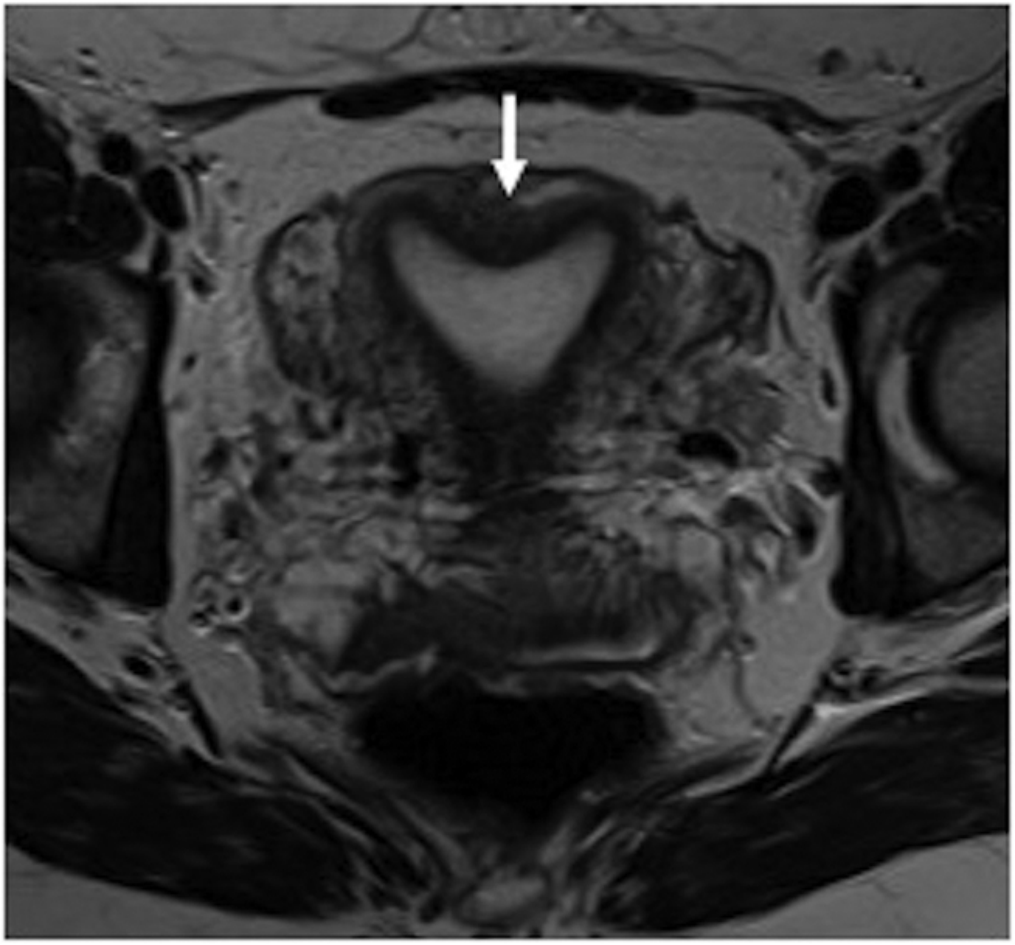


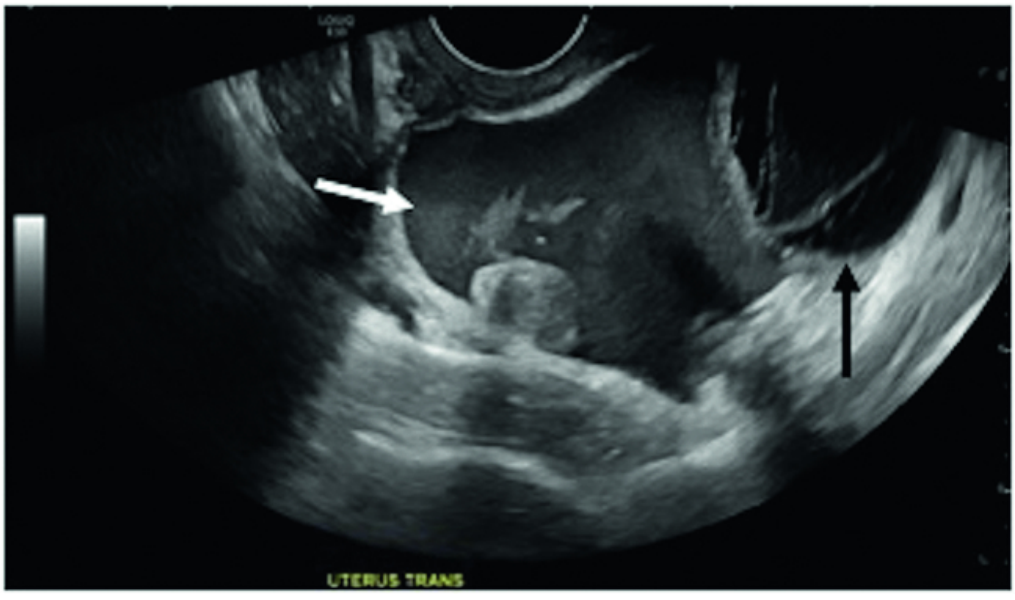

**FIGURE 4.4** **A.** Bicornuate uterus. MR image demonstrates diverging endometrial cavities (*arrows*) associated with errors of fusion as seen in a bicornuate uterus. **B.** Partial septate uterus. Partial septum is seen (*arrow*) within the fundal endometrium with absence of a fundal cleft on MRI, seen in partial septate uterus.

## IMAGING FOR ACUTE PELVIC PAIN AND ABNORMAL UTERINE

# BLEEDING

## Cyst Rupture and Hemorrhagic Cysts

Ovarian cysts are common and often rupture resulting in acute abdominal pain. The abdominal pain can be severe particularly when there is bleeding into the peritoneum. When this clinical scenario is suspected, the imaging study of choice is transvaginal ultrasound, which will typically show lacelike septations, heterogeneous hypoechoic material, and a retractile clot without vascularization on color Doppler US. Hemoperitoneum will show moderate level echoes on US. If CT is ordered, findings of hemorrhagic cyst include high heterogeneous attenuation and CT can detect fluid in the pelvis with possible extension into the abdomen depending on the extent of hemorrhage. On MRI, hemorrhagic cyst commonly demonstrates high T1 signal and low T2 signal without evidence of enhancement on post gadolinium series (**FIG. 4.5**).

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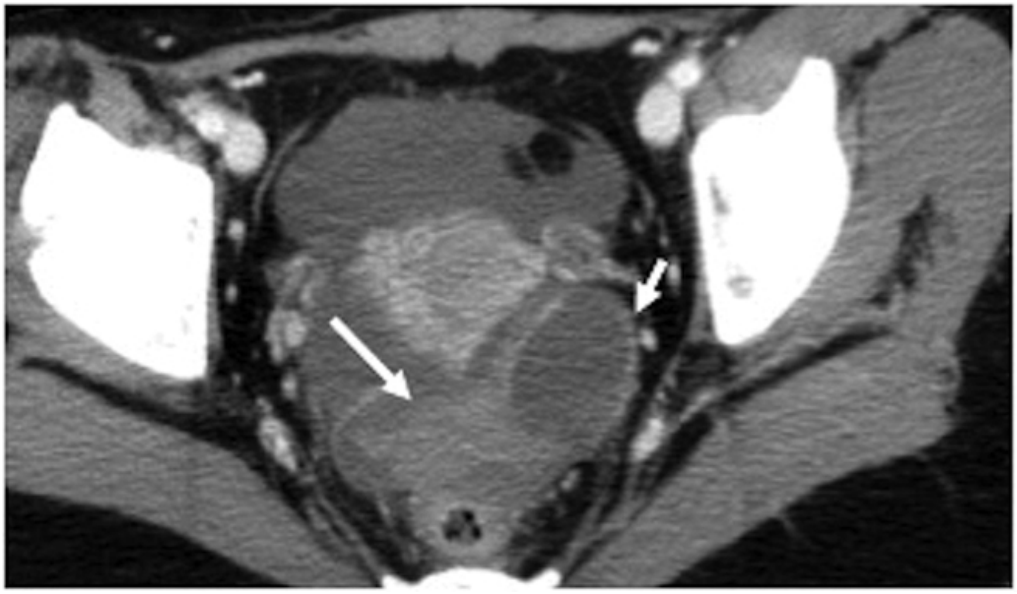
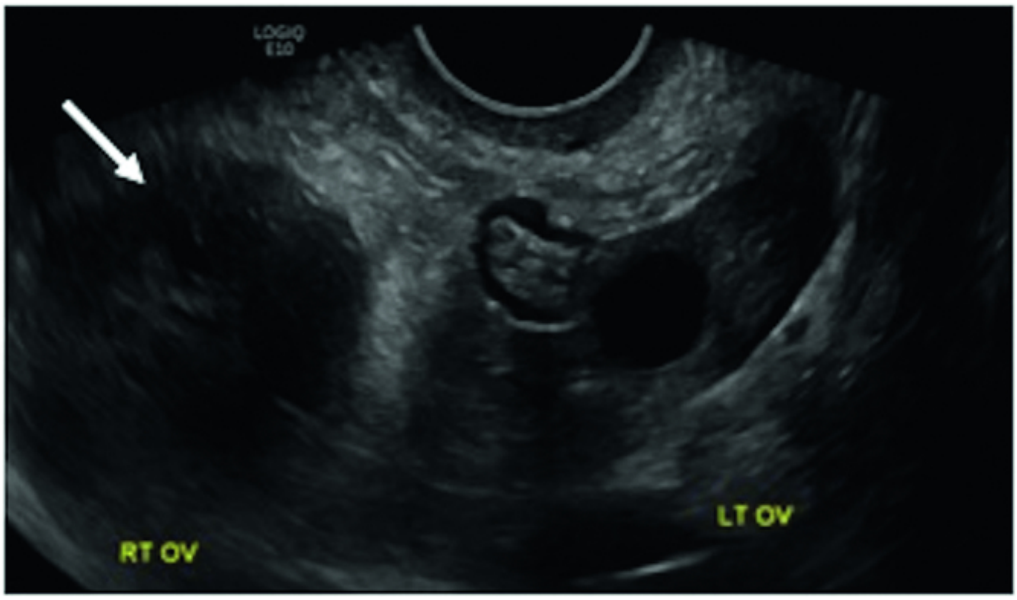



**FIGURE 4.5** **A.** Hemorrhagic cyst and hemoperitoneum. Endovaginal ultrasound demonstrates complex free fluid consistent with hemoperitoneum (*white arrow*) in the pelvis with a partially imaged ovarian cyst, which demonstrates lacelike reticular internal echoes and septations, consistent with a ruptured hemorrhagic cyst (*black arrow*). **B.** Concurrent contrast CT image confirms the presence of hemoperitoneum (*long arrow*) and a left adnexal hemorrhagic cyst (*short arrow*).

## Ovarian Torsion and Tubal Torsion

Ovarian torsion is another common reason for acute abdominal pain and is associated with the presence of ovarian masses, most commonly ovarian cysts and dermoids. Hypermobility of ovaries can also cause torsion without the presence of any mass. US imaging is

typically ordered for evaluation and shows asymmetrical enlargement of ovary, edema of ovarian parenchyma, midline position of the ovary, and swirling of the adnexal vascular pedicle and free fluid. The ovary can appear heterogeneous with diffuse edema, hemorrhage, cystic changes, and displaced follicles due to stromal edema. Doppler findings typically show absent or decreased venous flow and absent or decreased arterial flow; however, normal Doppler flow can also occasionally be present. CT is particularly helpful for the demonstration of fat stranding and edema in the adnexa and findings of hemorrhagic necrosis. MRI would show high T1 signal heterogeneously focally or diffusely in the ovarian parenchyma suggestive of hemorrhagic necrosis (**FIG. 4.6**).

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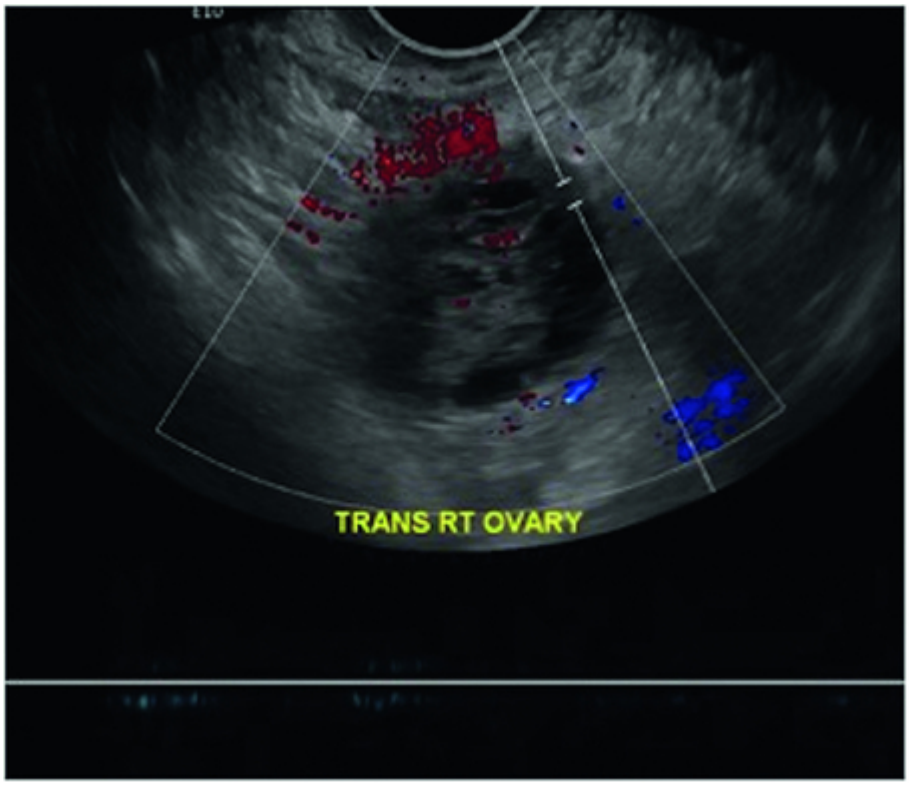



**FIGURE 4.6** Acute ovarian torsion. **A.** Endovaginal ultrasound demonstrates asymmetric enlargement of the right ovary (*arrow*). **B.** Note internal vascularity is noted on the spectral Doppler ultrasound image. Findings are consistent with acute ovarian torsion.

Tubal torsion can be seen in combination with ovarian torsion and is rarely seen in isolation. Typical imaging findings include a thickened tube with thick walls, dilated tubes, and adjacent fat stranding. A torsed tube and associated vascular pedicle swirling can also been seen in some patients, and this diagnosis requires high level of suspicion in the presence of acute severe pain.

# Pelvic Inflammatory Disease and Tuboovarian Abscess

Pelvic inflammatory disease is usually bilateral and results from the ascending spread of micro-organisms from the vagina and cervix to the endometrium, fallopian tubes, ovaries, and adjacent peritoneal space. There is no specific radiologic finding for PID. In cases of PID with severe cervicitis, cervical enlargement with increased vascularity on color Doppler and heterogeneous edematous appearance is found; if cervicitis is not severe, no specific imaging findings will be detected. Increased enhancement can also be seen on CT and MR imaging. Endometritis can result in an edematous uterus and endometrium with thickened lining, increased vascularization on color Doppler study; fluid or air can also be seen in the endometrial cavity. Salpingitis is characterized by thickened and edematous fallopian tubes, which is usually associated with adjacent fat stranding, increased vascularization on color Doppler, or increased enhancement of the tubes. Salpingitis is usually associated with oophoritis, which is characterized by edema and mild enlargement of ovary and adjacent fat stranding. Hydrosalpinx and pyosalpinx are additional findings. On MRI, dilated tubes show high T1 signal due to proteinaceous debris, which is common when pyosalpinx is present.

If a pelvic infection is suspected to be due to a tuboovarian abscess (TOA), a contrast-enhanced CT is the preferred initial imaging examination. Findings of a TOA include a multilocular complex fluid collection involving the adnexa showing heterogeneous appearance with internal debris and thick irregular walls and septations and fat stranding. Color Doppler imaging, combined with ultrasound, will show increased surrounding vascularization. Complex fluid inside the abscess can show variable heterogeneous echogenicity on US and heterogeneous attenuation on CT. The development of gas in abscess can be seen on US (**FIG. 4.7**).

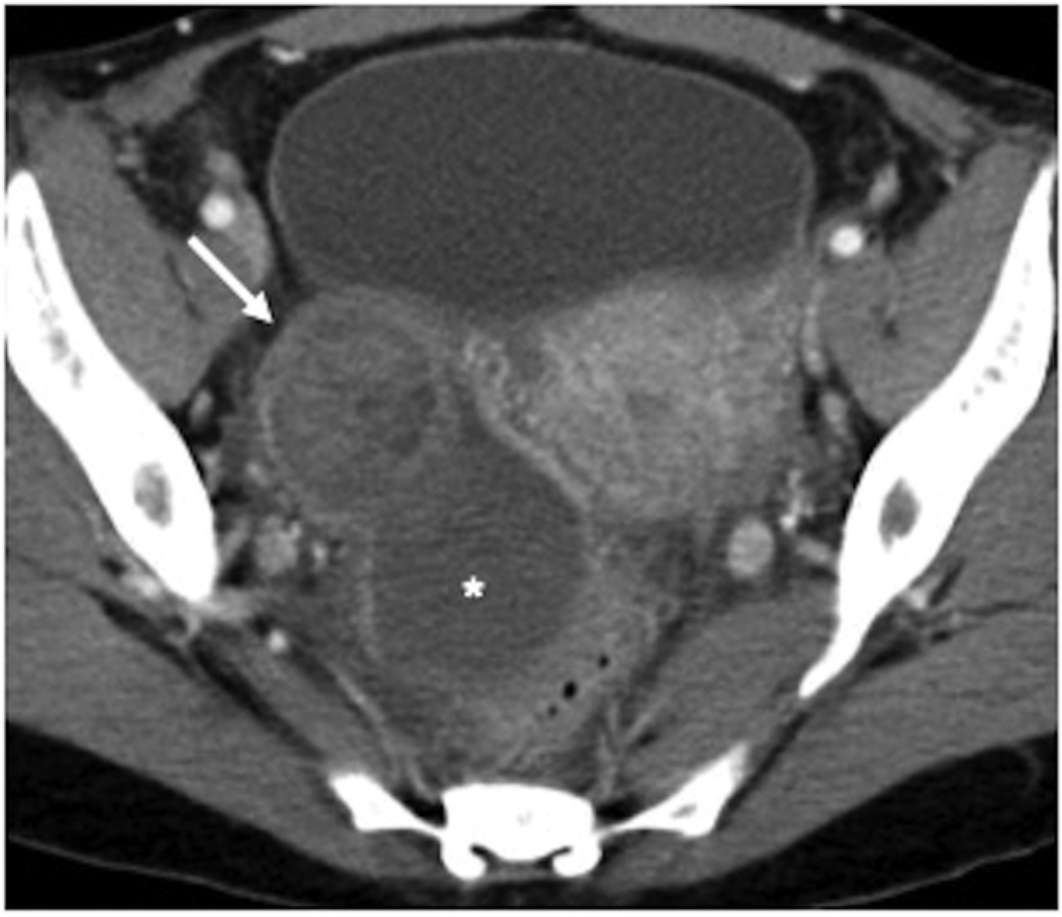


**FIGURE 4.7** Tuboovarian abscess. CT image confirms the presence of a thick-walled fluid collection (*asterisk*) in the pelvis between the uterus, rectum, and right ovary (*arrow*) with surrounding inflammatory changes, which in the setting of fevers and leukocytosis was consistent with a tuboovarian abscess.

## Endometrial Polyps

Endometrial polyps are sessile and pedunculated lesions arising from hyperplastic overgrowths of endometrial glands and stroma around a vascular pedicle and are almost always benign.

Endometrial polyps can be multiple and cause premenopausal and postmenopausal bleeding. Polyps are difficult to detect on endovaginal US and therefore requires high level of suspicion. The polyps are usually hyperechoic or isoechoic to the endometrium, which may interrupt the regular contours of endometrium. The presence of vascular pedicle with fibrous core is highly specific for the detection polyps. Polyps can also be seen as focal or diffuse endometrial thickening, particularly if the polyp fills the endometrial cavity completely. Sonohysterosonography has high accuracy for the detection of polyps and is the initial study of choice. MRI can also confirm the presence of polyps as they demonstrate isointense to slightly low T2 signal, and the fibrous vascular core shows low T2 signal. The most common differential diagnosis is submucosal fibroid. The presence of associated thick junctional zone and their myometrial origin will differentiate submucosal fibroids from polyps.

# Endometriosis and Adenomyosis

Adenomyosis and endometriosis are common chronic nonneoplastic gynecological conditions characterized by ectopic endometrium implanted in myometrium or outside of the uterus. MRI has a high sensitivity and specificity for diagnosis of both disease processes.

Two main patterns of involvement in the setting of adenomyosis can lead to two discrete imaging patterns: diffuse involvement of the myometrium, which manifests as a diffusely enlarged uterus, or localized involvement known as an adenomyoma. In some cases, focal manifestations can be difficult to distinguish from leiomyomas.

Sonographic features of adenomyosis include an enlarged, globular uterine contour, irregularity of the endometrial/myometrial junction, subendometrial cysts, and “Venetian blind” appearance of linear striations. MR imaging features of adenomyosis include ill-defined low T2 signal thickening of the junctional zone due to smooth muscle proliferation, and ectopic endometrium appears as scattered T2 hyperintense cystic foci with associated variable T1 signal.

Endometriosis is characterized by three different patterns: superficial (peritoneal) disease, ovarian (endometrioma), and deep infiltrating endometriosis (DIE). Superficial endometriosis is difficult

to identify radiographically, and these cases are best evaluated with diagnostic laparoscopy. Endometriomas appear as unilocular cysts with homogeneous low-level internal echoes by sonography and as can be diagnosed with high accuracy on MRI. Bilaterality and multifocality of adnexal lesions with these imaging features are common and increases the specificity (**FIG. 4.8**).

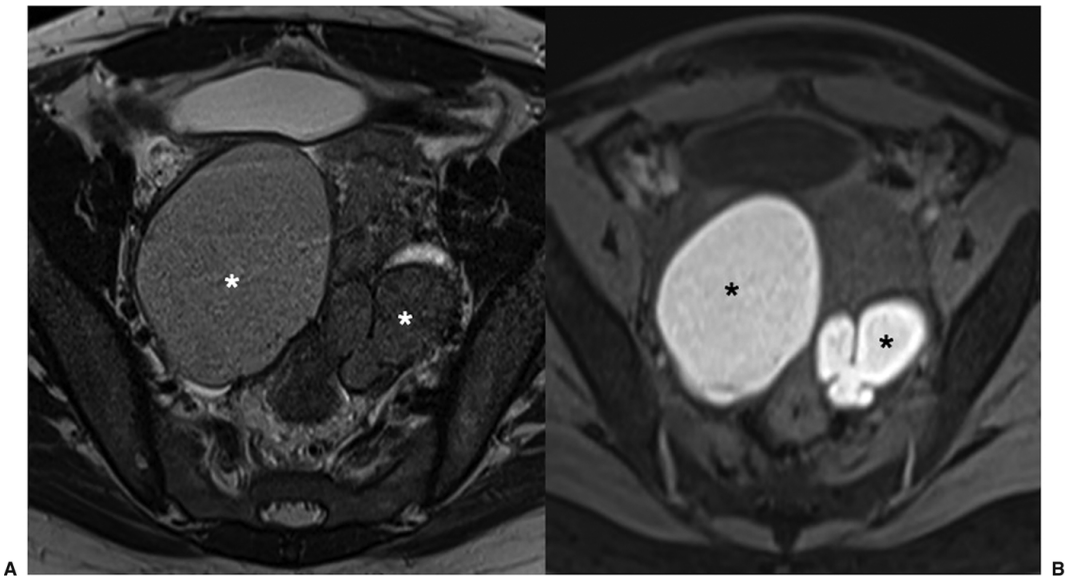



**FIGURE 4.8** Endometrioma. MRI of the pelvis demonstrates bilateral adnexal lesions with **(A)** intrinsic T2 shading **(B)** T1 hyperintensity compatible with bilateral endometriomas (*asterisks*).

DIE is defined as subperitoneal involvement by endometriotic implants >5 mm in depth. While some implants can be detected by their intrinsic MRI T1 hyperintense signal due to the presence of more recent blood products, many solid fibrotic endometriotic implants show predominately T2 intermediate signal and hypointense signal and when closely approximated to other normal anatomic structures and can be easily overlooked due to their isointense signal. DIE can occur in atypical locations outside of the

pelvis including the upper abdomen, thorax, or along scars in the anterior abdominal wall.

# IMAGING FINDINGS FOR COMMON BENIGN NEOPLASTIC DISEASE PROCESSES

## Fibroids

Fibroids are benign tumors of myometrial origin and the most common uterine neoplasm encountered. While ultrasound is typically the first choice for imaging for identification fibroids, MRI is the most accurate for detecting, localizing, and characterizing fibroids while excluding other potential mimickers. Furthermore, MRI can play a vital role in determining eligibility for planning and monitoring treatment response after uterine artery embolization (UAE).

The classic appearance of a fibroid is a circumscribed, hypoechoic solid mass with posterior shadowing with or without calcifications seen on US. Increased internal echogenicity can be seen in the setting of a lipoleiomyoma. On MRI, a fibroid will appear as a T1 isointense, T2 hypointense mass with variable enhancement. Several forms of fibroid degeneration will deviate from the classic fibroid appearance. Hyaline degeneration is associated with heterogeneous to no internal enhancement, or myxoid or cystic degeneration can be seen. There are no reliable imaging features that reliably distinguish a leiomyosarcoma from a degenerated fibroid (**FIG. 4.9**).

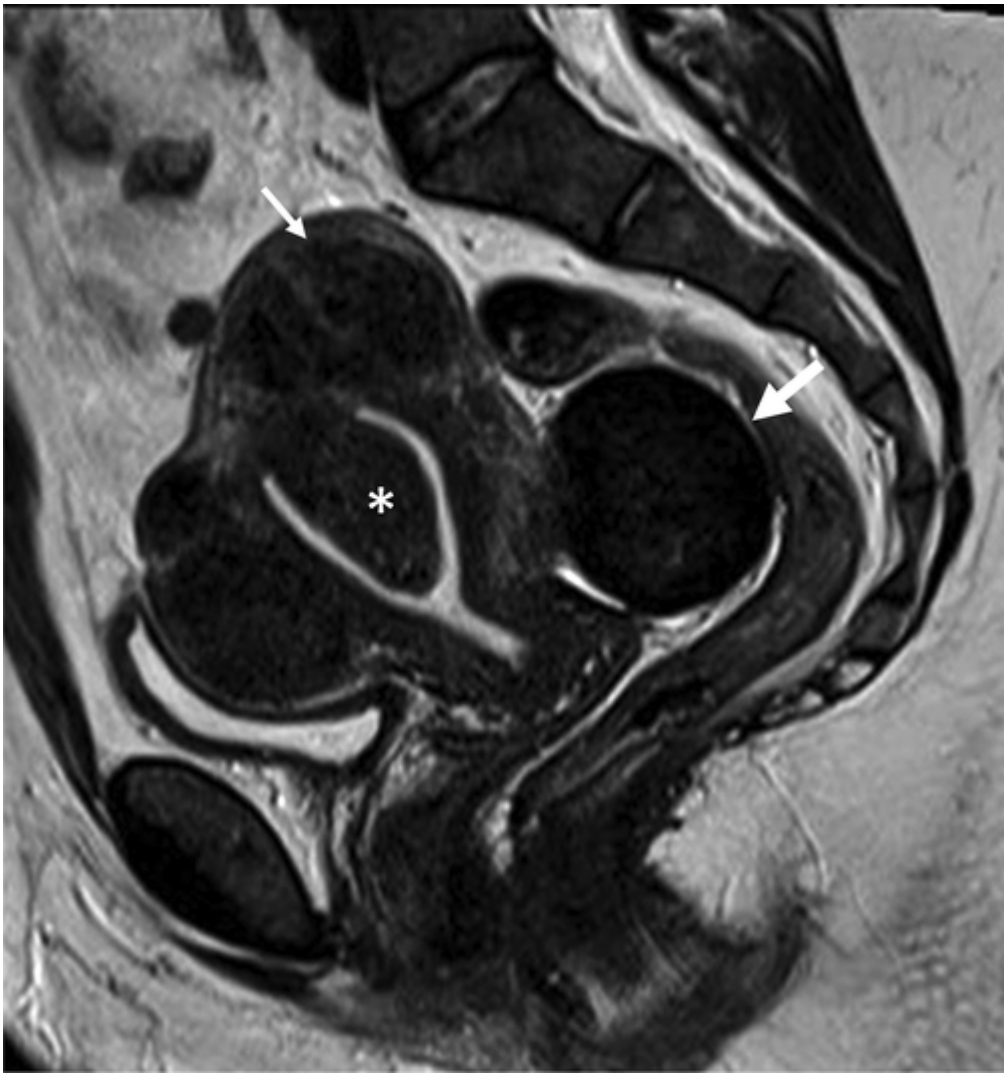


**FIGURE 4.9** Fibroids. MR image of the pelvis demonstrates multiple intracavitary (*asterisk*), intramural (*white thin arrow*), and subserosal/pedunculated (*white thick arrow*) fibroids.

## Dermoid Cysts

Ovarian teratoma, or dermoid cyst, is a common ovarian neoplasm, which includes variable amounts of mature or immature tissue arising from the ectoderm, mesoderm, and/or endoderm. On US, a

typical dermoid will demonstrate cystic components with a densely echogenic nodular component, which is also known as the Rokitansky nodule or dermoid plug. Uncommonly but typically, they may be seen as floating intracystic echogenic balls. Other sonographic features include calcifications/tooth, or internal debris in a “dot-dash” pattern, which is sonographic appearance of hair within sebaceous material. CT and MRI can easily detect intratumoral fat, which is a characteristic imaging feature associated with dermoids. Intratumoral calcification is often present and is best seen on CT (**FIG. 4.10**).

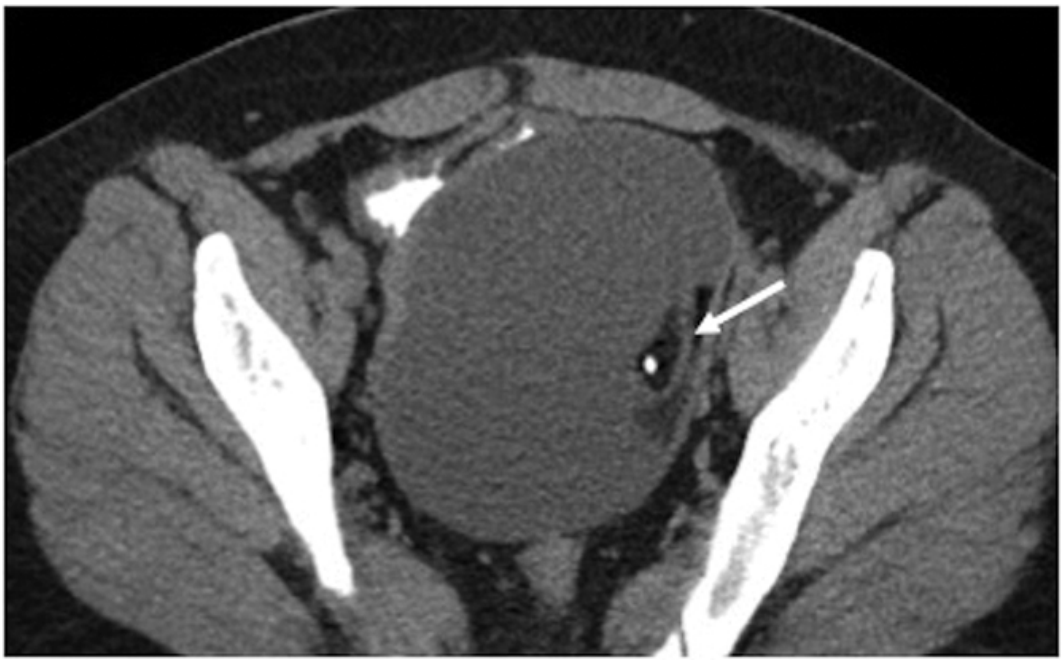


**FIGURE 4.10** Dermoid. CT image of an ovarian dermoid demonstrating large cystic component with punctate calcification and macroscopic fat along the periphery on the left side (*arrow*).

Various complications associated with ovarian teratomas can result in atypical imaging manifestations. For example, dermoid is the most

common ovarian mass associated with ovarian torsion, which can present as a diffusely enlarged and edematous ovary with peripheralized follicles, twisted vascular pedicle, and variable internal venous and arterial flow. Cyst rupture can present as new ascites with clinical findings of peritonitis, which can mimic peritoneal carcinomatosis, although in some cases focal floating fat may be appreciated.

# IMAGING FINDINGS OF COMMON CYSTIC LESIONS OF LOWER GENITOURINARY TRACT

## Urethral Diverticulum

Urethral diverticulum most commonly arises from the posterolateral wall of the midurethra, usually at the level of symphysis pubis. MRI is the best imaging modality for the assessment. One of the critical features of diverticulum that should be determined on MRI include its exact location, which can be described according to clock face template on axial T2-weighted images, and this is helpful for surgical planning. The diverticulum may have a narrow or wide neck or could be unilocular vs multilocular with multiple septations. The diverticulum could be an oval simple diverticulum although U-shaped or circumferential diverticula can also be seen. Septations, layering debris, and fluid levels can be seen in the complex diverticula, which could also be infected.

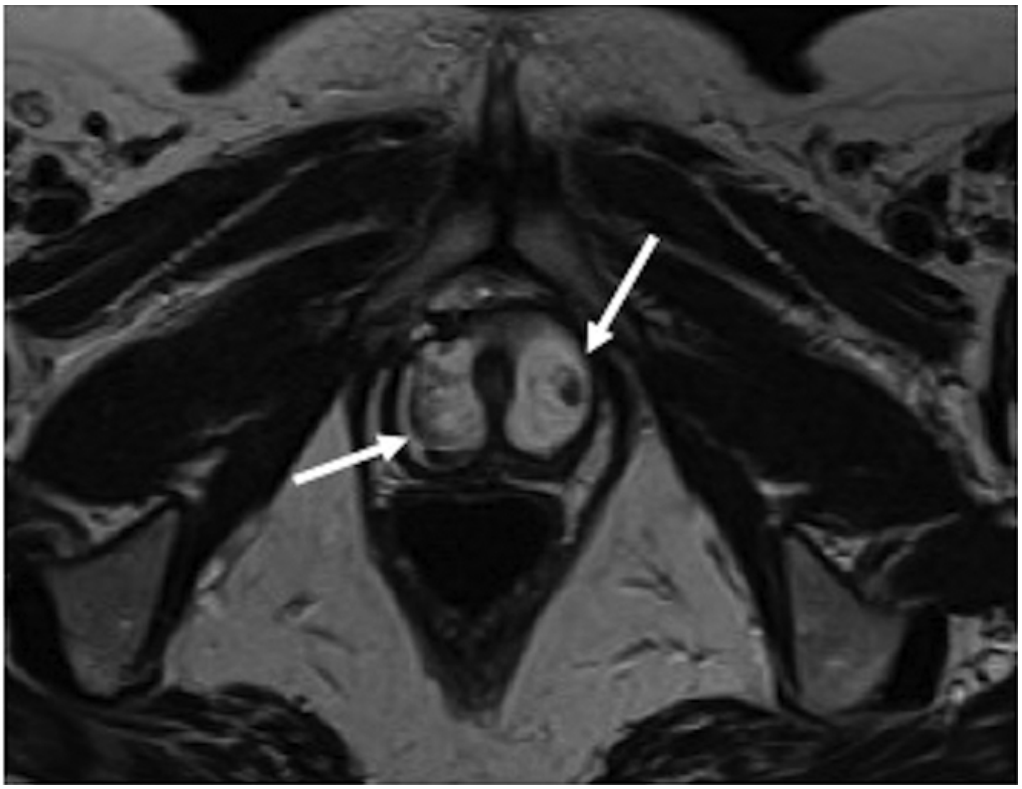
Calculus formation, infection, and malignancy development are the three main complications of urethral diverticulum. The most feared complication of the urethral diverticulum is the development of malignancy inside the diverticulum although this is very rare. This manifested as a mass arising from the urethral diverticulum and is seen as enhancing soft tissue, usually with irregular contours with possible infiltrative potential to the surrounding tissues.

## Vulvar and Vaginal Cysts

Gartner duct cysts arise from the residual mesonephric duct remnants (Wolffian) ducts and are also secretory retention cysts. Typically, these unilocular cysts are located along the anterolateral vaginal wall above the level of inferior border of the symphysis pubis. The best study to evaluate and diagnose these cysts is MRI.

Skene duct cysts result from the inflammatory ductal obstruction of the paraurethral Skene glands. They are located on both sides of the external urethral meatus inferior to the symphysis pubis. These are also best evalluated by MRI.

Bartholin gland cysts develop secondary to ductal obstruction due to chronic inflammation and infection of the Bartholin glands, which are located at the posterolateral wall of the inferior third of the vagina at or below the level of symphysis pubis. These cysts are usually unilocular and demonstrate high T2 signal with variable T1 signal depending on the protein and mucin content. These cysts usually demonstrate mild to moderate peripheral wall enhancement. If the cyst is multilocular and shows heterogeneous T1 and T2 signal with intense wall enhancement associated with pericystic soft tissue edema and inflammation, infection should be suspected, and this can easily be confirmed clinically. Perineal endometriosis and injected collagen can also cause development of periurethral cysts, and epidermal inclusion cysts can also be seen in this region (**FIG. 4.11**).



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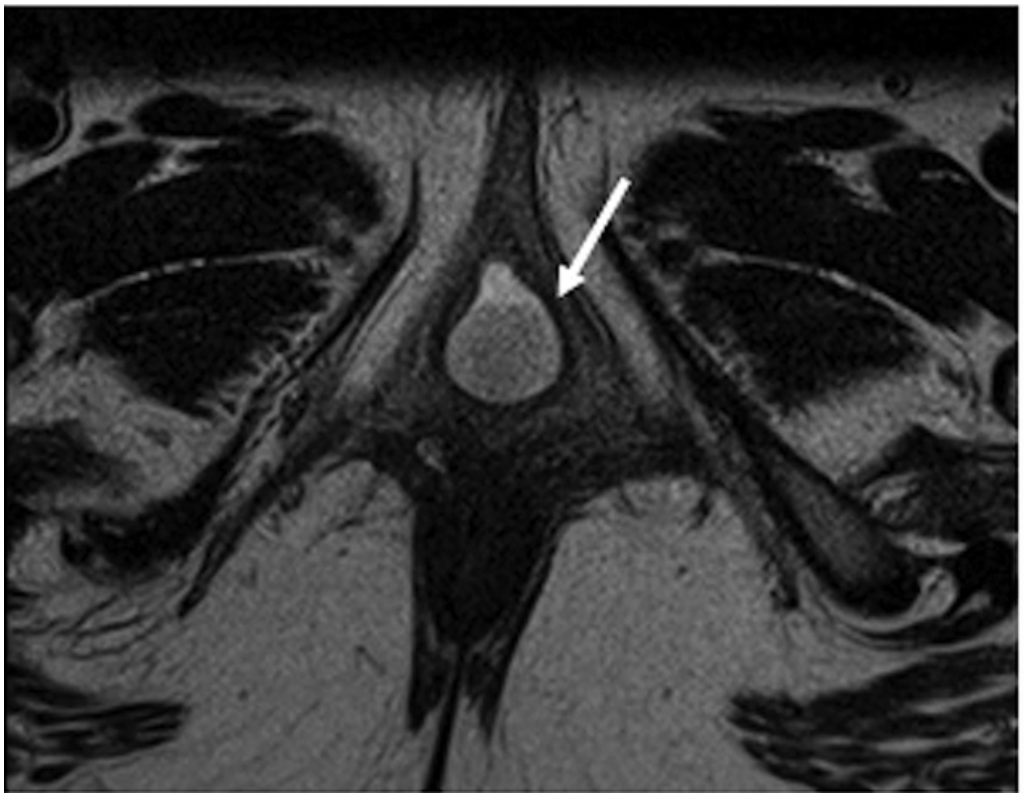

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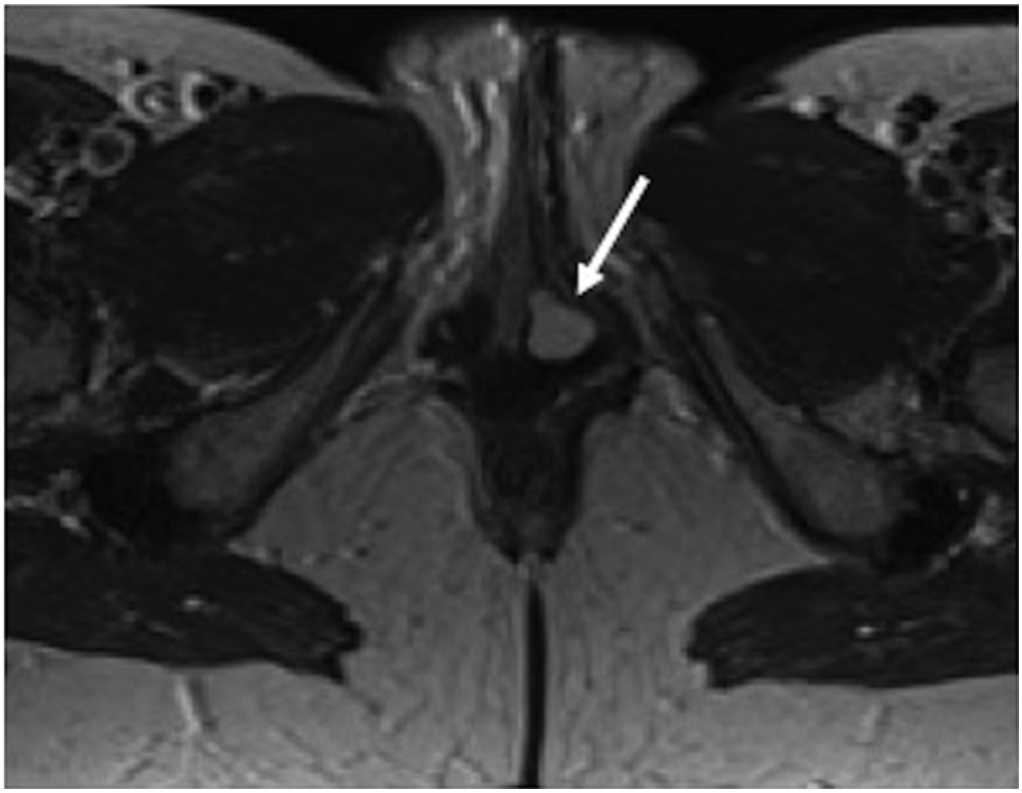


C

**FIGURE 4.11** Cystic lesions of lower genitourinary tract. **A.** Urethral diverticulum. A circumferential diverticulum (*arrows*) is seen surrounding the urethra located centrally at the level of mid-urethra. **B.** Skene gland cyst. A debris-filled paraurethral ("Skene" gland) cyst (*arrow*) is seen at the midline adjacent to the inferior urethra. **C.** Bartholin gland cyst. A cyst (*arrow*) is seen along the left lateral wall of distal vagina.

## IMAGING FINDINGS FOR GYNECOLOGIC CANCERS

# Cervical Cancer

Imaging plays a significant role in staging, treatment planning, monitoring treatment response, and posttreatment surveillance of cervical cancer. CT is often ordered as a first choice due to ease of scheduling and that it is quick to perform to obtain rapid assessment of nodal status. However, MRI is the better modality for cervical cancer pelvic staging due to its high soft tissue contrast resolution and is superior to CT in the determination of pelvic tumor size and relationship of the tumor to adjacent structures. MRI is highly accurate for confirmation of soft tissue invasion of the parametrium, and information from imaging may impact the decision to offer radical hysterectomy for clinically staged early disease. It can also successfully detect invasion and assess the relationship of adjacent organs relative to the tumor such as pelvic sidewall, ureters, bladder, rectum, bowel loops, nerves, and bones. MRI can exclude parametrial involvement if cervical stroma is seen and can detect the extent of vaginal invasion with relatively high accuracy; accuracy increases with the use of vaginal gel, which is essential for the differentiation of stages II and III disease (**FIG. 4.12**).

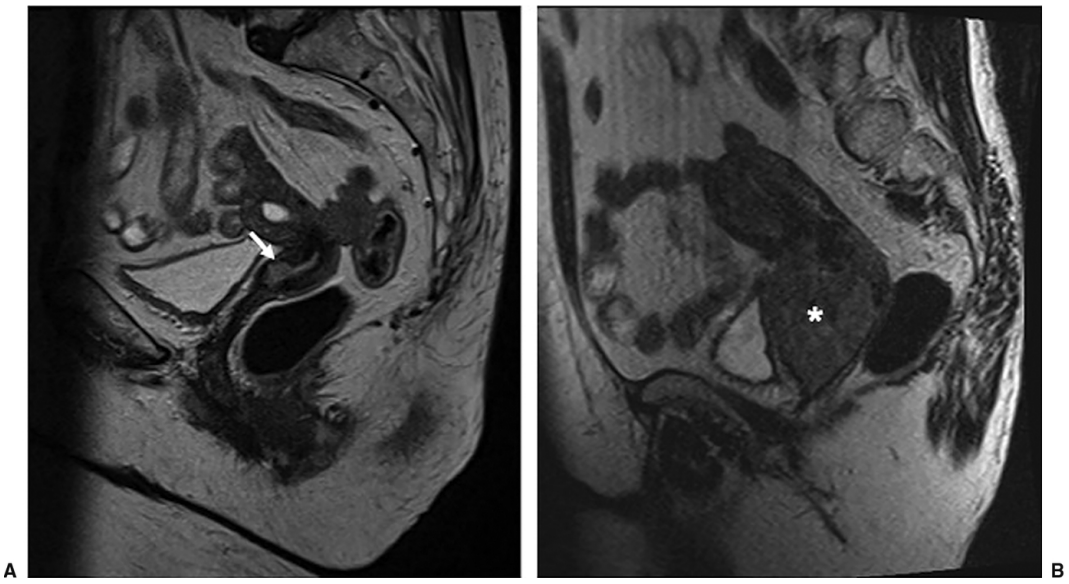



**FIGURE 4.12** Cervical cancer. MRI of the pelvis demonstrating a small cervical cancer,

with a mass confined to the anterior cervix (*arrow*) **(A)** and with a larger mass (*asterisk*) **(B)** showing evidence of vaginal invasion and parametrial invasion.

MRI can be used for surgical planning for trachelectomy in cervical cancer patients who desire preservation of fertility and are eligible for fertility sparing treatment. It can successfully verify the absence of disease at the internal os, which is an eligibility criterion for trachelectomy and cannot be assessed with physical examination.

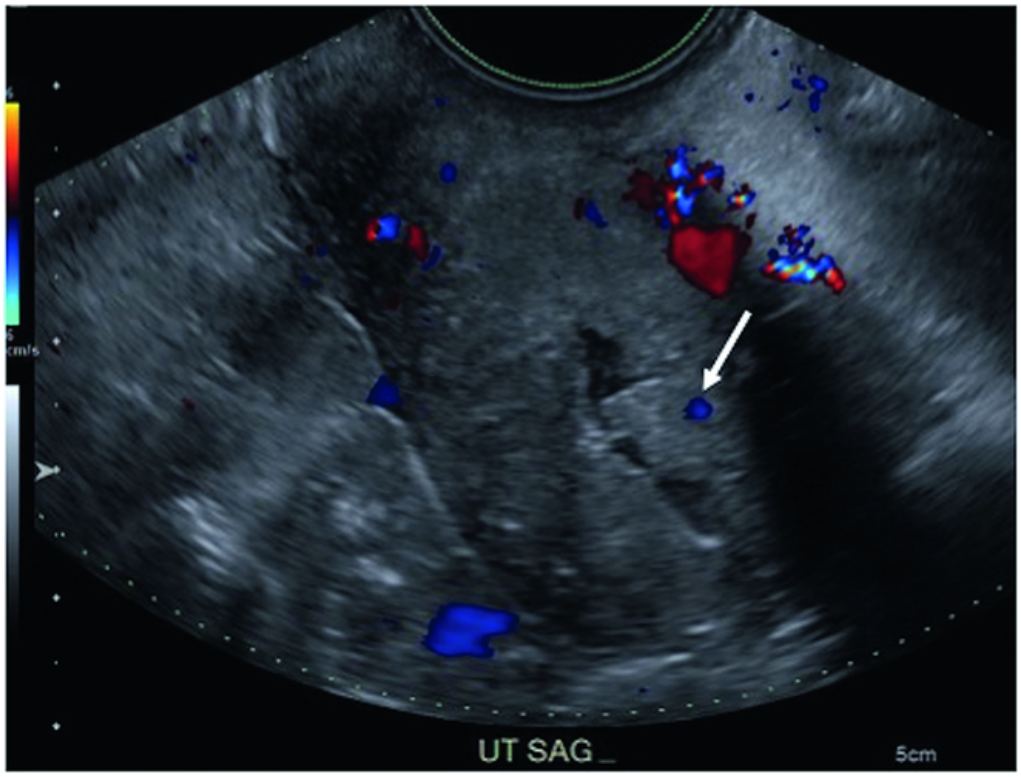
MRI has low accuracy for the identification of metastatic lymph nodes due to its inability to detect microscopic disease in normal-appearing false-negative lymph nodes and inability to differentiate reactive inflammatory changes in enlarged reactive lymph nodes. However, the accuracy of MRI increases for the detection of lymph nodes when the tumor is bulky and lymph nodes show round morphology, heterogeneous enhancement, and necrosis. CT can be ordered for the diagnosis of distant metastases such as disease in pelvic lymph nodes. CT scans are easily ordered and quick to perform so can be an initial study for assessment of metastatic disease, which can significantly impact treatment choices. Ultrasound is usually not ordered for the assessment of cervical cancer.

# Endometrial and Uterine Cancers

The role of imaging for endometrial endometrioid cancer is similar to that of cervical cancer. In patients with vaginal bleeding, transvaginal ultrasonography is the initial method of evaluation and can detect endometrial thickening with high accuracy and determine the need for endometrial biopsy when invasive cancer has not yet been diagnosed. However, the role of ultrasound for the assessment of myometrial invasion in cases of documented invasive disease is limited and therefore is not used for staging. MRI is the best modality for the assessment of myometrial invasion, cervical involvement,

uterine serosa, or adnexa involvement; vaginal or parametrial involvement; and bladder/rectum or bowel involvement. Myometrial invasion can be diagnosed or excluded with MRI. CT, PET-CT, or PET-MRI can be requested for the assessment of lymph nodes and distant disease.

Imaging findings of uterine sarcomas are not specific, and MRI is again the preferred modality for local staging once diagnosed. These tumors demonstrate variable enhancement patterns with overall heterogeneous enhancement. The utility of PET-CT, PET-MRI, and CT imaging for sarcomas is similar to other cancers (**FIGS. 4.13 and 4.14**).




**A**

**FIGURE 4.13** Endometrial cancer. **A.** Focal endometrial mass (*arrow*) with lobulated contours and increased vascularization in the endometrial cavity on the sagittal US image. **B.**The corresponding mass on MRI (*arrow*).

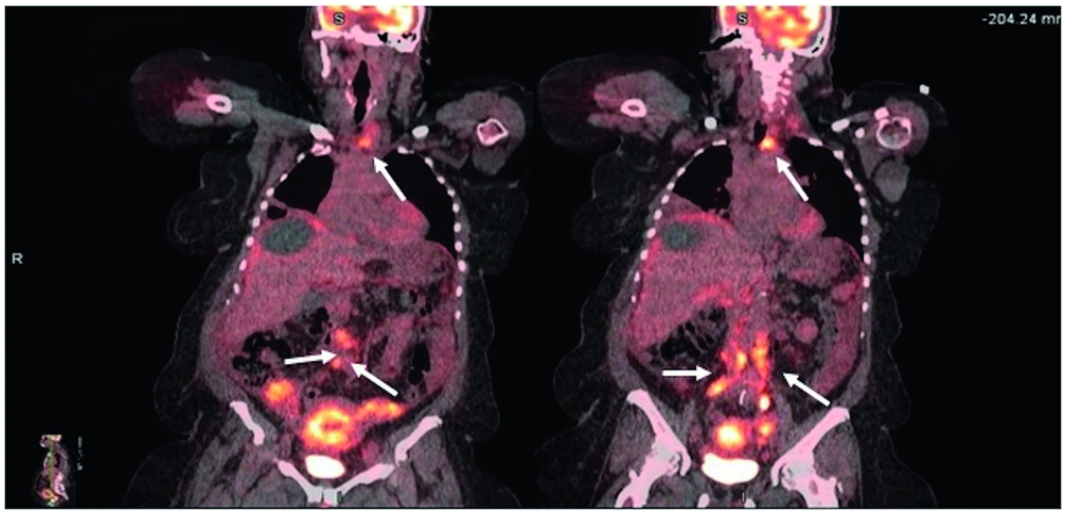



**FIGURE 4.14** Endometrial cancer. PET/CT images with 18F-FDG in a patient with endometrial cancer demonstrates abnormal uptake in the endometrium, myometrium, and bilateral ovaries, as well as hypermetabolic lymph nodes compatible with nodal metastases extending to the retroperitoneal nodal chain (*arrows*) and the level of the superior mediastinum (*arrow*).

## Vaginal and Vulvar Cancer

Role of imaging for vaginal and vulvar cancer is similar to that of cervical and endometrial cancer. MRI is the preferred imaging modality for the assessment and staging of vaginal and vulvar cancers. Intravaginal gel is used during the assessment of vaginal cancers.

The extension of vaginal tumor to the paravaginal soft tissues can be diagnosed using MRI. PET/CT and PET/MRI can be helpful for the assessment of lymph nodes in the inguinal chain and perirectal region (drainage of lower third of vagina), common iliac and internal iliac chain (drainage of middle third of vagina), and

external iliac chain and para-aortic chain (drainage of upper third of vagina).

The role of MRI for the identification of underlying soft tissue invasion in early vulvar cancers (T1, Stage 1 disease) is not well established. However, MRI can assess the invasion of the perineum, lower vagina, lower urethra, and anus. PET-CT and PET-MRI can be ordered for determining whether there is metastatic disease in inguinofemoral lymph nodes.

# Ovarian Cancer

Preoperative imaging for ovarian neoplasms is used for the determination of ovarian or adnexal origin, characterization of the masses, and evaluation for metastatic disease.

The presence of normal ovarian parenchyma around an adnexal mass is suggestive of ovarian origin. Additionally, if the ovary cannot be identified, the mass can be assumed as an adnexal mass if the vascular pedicle is associated with gonadal vessels and/or the mass does not arise from other adjacent structures.

Imaging can be helpful for the characterization of indeterminate adnexal masses to some extent with the addition of clinical and laboratory findings. If the mass contains fat on imaging, the differential diagnosis includes mature or immature teratoma. If the mass contains solid components with low T2 signal on MRI, the differential diagnosis includes fibroma, fibrothecoma, Brenner tumor, adenofibroma, and cystadenoma fibroma.

If the mass does not contain fat or solid components with low T2 signal on MRI, the differential diagnosis depends on the age (below or above 30 years of age) and internal architecture of the mass. If the patient is younger than 30 years old, juvenile granulosa cell tumor, dysgerminoma, choriocarcinoma, yolk sac tumor, and embryonal carcinoma are in the differential diagnosis.

For patients who are older than 30 years, the differential diagnosis depends on internal architecture of the mass with the following characteristics: (1) predominantly solid, (2) solid and cystic, and (3) predominantly cystic consistency. Discriminating ovarian architecture by these characteristics can further clarify a diagnosis of

serous neoplasms, mucinous neoplasms, endometrioid carcinoma, clear cell carcinoma, adult granulosa cell tumor, metastatic disease, and ovarian lymphomas. Some tumors tend to be bilateral such as high-grade serous carcinomas or metastases. Tumors may have associated clinical and lab findings, which, when combined with imaging findings, will help to make a diagnosis.

CT is often the initial study for evaluation of advanced ovarian cancer. Ct imaging can identify omental caking, peritoneal or mesenteric disease, and enlarged metastatic lymph nodes quickly. Information from imaging is used to follow chemotherapy treatment or assess the feasibility of surgical debulking. There are clinical scenarios where MRI and PET/CT imaging will add to clinical assessment (**FIG. 4.15**).

A

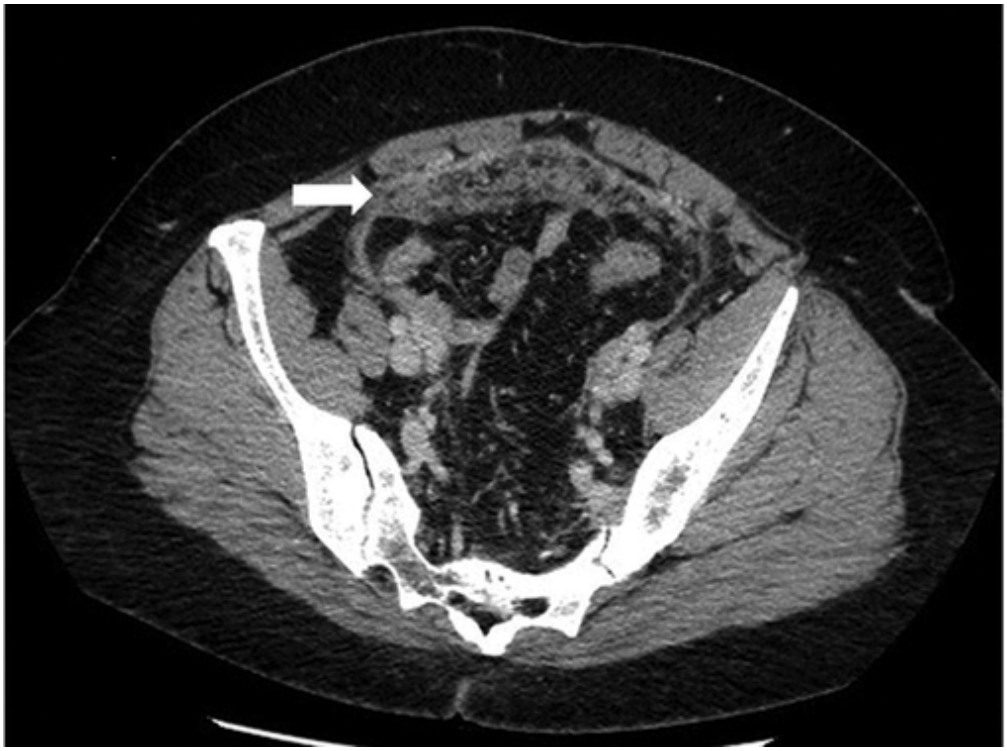



**FIGURE 4.15** Ovarian cancer. **A.** CT image of an enhancing mixed cystic and solid left ovarian mass corresponding to biopsy-proven high-grade serous carcinoma (*arrow*). A small amount of pelvic ascites and mild peritoneal thickening is also present. **B.** Peritoneal carcinomatosis. CT image of the lower abdomen demonstrating diffuse omental thickening or "caking" (*arrow*) in the setting of known underlying ovarian cancer with peritoneal carcinomatosis.

## O-RADS US AND O-RADS MRI CLASSIFICATION SYSTEM FOR

# ADNEXAL MASSES

When describing ovarian and adnexal lesions, variable and inconsistently applied terminology can significantly impact the study interpretation and management. The American College of Radiology's (ACR) response to this issue was the establishment of the Ovarian-Adnexal Reporting and Data System (O-RADS) in 2018. The goal of O-RADS is to create a standardized lexicon for describing ovarian and adnexal lesions and to apply the lexicon to a risk stratification classification.

## Risk Stratification Based on Ultrasound

Ultrasound is the first-line imaging modality for evaluation of an ovarian or adnexal lesion. O-RADS ultrasound (O-RADS US) categorizes the adnexal lesions into categories with different levels of risk assessment for malignancy based on predetermined US finding. ORADS-US also recommends further assessment with MRI and/or referrals for management based on the risk assessment and imaging findings. For example, in accordance with ORADS recommendations, simple cysts, defined as measuring 3 cm or more do not require any follow-up regardless of age. Simple cysts measuring >3 to 5 cm requires follow-up in 1 year in postmenopausal patients and no follow-up in premenopausal patients. Matching ultrasound findings to guidelines in ORADs will determine follow-up and management (**FIG. 4.16**).

ACR AMERICAN COLLEGE OF RADIOLOGY

## O-RADS™ US v2022 — Assessment Categories

Release Date: November 2022

| O-RADS Score | Risk Category [IOTA Model] | Lexicon Descriptors | | Management | |
|---|---|---|---|---|---|
| | | | | Pre-menopausal | Post-menopausal |
| 0 | Incomplete Evaluation [N/A] | Lesion features relevant for risk stratification cannot be accurately characterized due to technical factors | | Repeat US study or MRI | |
| 1 | Normal Ovary [N/A] | No ovarian lesion | | None | |
| | | Physiologic cyst: follicle (≤3 cm) or corpus luteum (typically ≤3 cm) | | | |
| 2 | Almost Certainly Benign [<1%] | Simple cyst | ≤3 cm | N/A (see follicle) | None |
| | | | >3 cm to 5 cm | None | Follow-up US in 12 months* |
| | | | >5 cm but <10 cm | Follow-up US in 12 months* | |
| | | Unilocular, smooth, non–simple cyst (internal echoes and/or incomplete septations) — Bilocular, smooth cyst | ≤3 cm | None | Follow-up US in 12 months* |
| | | | >3 cm but <10 cm | Follow-up US in 6 months* | |
| | | Typical benign ovarian lesion (Table 2) | <10 cm | See Table 2 (Classic Benign Lesions) for descriptors and management | |
| | | Typical benign extraovarian lesion (Table 2) | Any size | | |
| 3 | Low Risk Malignancy [1 – <10%] | Typical benign ovarian lesion (Table 2), ≥10 cm | | Imaging:<br>• If not surgically excised, consider follow-up US within 6 months**<br>• If solid, may consider US specialist (if available) *or* MRI (with O-RADS MRI score)***<br>Clinical: Gynecologist | |
| | | Uni- or bilocular cyst, smooth, ≥10 cm | | | |
| | | Unilocular cyst, irregular, any size | | | |
| | | Multilocular cyst, smooth, <10 cm, CS <4 | | | |
| | | Solid lesion, ± shadowing, smooth, any size, CS = 1 | | | |
| | | Solid lesion, shadowing, smooth, any size, CS 2–3 | | | |
| 4 | Intermediate Risk [10 – <50%] | Bilocular cyst without solid component(s) | Irregular, any size, any CS | Imaging:<br>Options include:<br>• US specialist (if available) *or*<br>• MRI (with O–RADS MRI score)*** *or*<br>• Per gyn–oncologist protocol<br>Clinical: Gynecologist with gyn–oncologist consultation *or* solely by gyn–oncologist | |
| | | Multilocular cyst without solid component(s) | Smooth, ≥10 cm, CS <4 | | |
| | | | Smooth, any size, CS 4 | | |
| | | | Irregular, any size, any CS | | |
| | | Unilocular cyst with solid component(s) | <4 pps or solid component(s) not considered a pp; any size | | |
| | | Bi- or multilocular cyst with solid component(s) | Any size, CS 1–2 | | |
| | | Solid lesion, non-shadowing | Smooth, any size, CS 2–3 | | |
| 5 | High Risk [≥50%] | Unilocular cyst, ≥4 pps, any size, any CS | | Imaging: Per gyn-oncologist protocol<br>Clinical: Gyn-oncologist | |
| | | Bi- or multilocular cyst with solid component(s), any size, CS 3–4 | | | |
| | | Solid lesion, ± shadowing, smooth, any size, CS 4 | | | |
| | | Solid lesion, irregular, any size, any CS | | | |
| | | Ascites and/or peritoneal nodules**** | | | |

**GLOSSARY**

| | |
|---|---|
| Smooth and irregular: refer to **inner** walls/septation(s) for **cystic** lesions, and **outer** contour for **solid** lesions; irregular inner wall for cysts = <3 mm in height | Solid: excludes blood products and dermoid contents; solid lesion = >80% solid; solid component = protrudes ≥3 mm (height) into cyst lumen off wall or septation |
| Shadowing: must be diffuse or broad to qualify; excludes refractive artifact | pp = papillary projection; subtype of solid component surrounded by fluid on 3 sides |
| CS = color score; degree of intralesional vascularity; 1 = none, 2 = minimal flow, 3 = moderate flow, 4 = very strong flow | Bilocular = 2 locules; multilocular = ≥3 locules; bilocular smooth cysts have a lower risk of malignancy, regardless of size or CS |

*Shorter imaging follow-up may be considered in some scenarios (eg, clinical factors). If smaller (≥10–15% decrease in average linear dimension), no further surveillance. If stable, follow-up US at 24 months from initial exam. If enlarging (≥10–15% increase in average linear dimension), consider follow-up US at 12 and 24 months from initial exam, then management per gynecology. For changing morphology, reassess using lexicon descriptors. **Clinical management with gynecology as needed.**

**There is a paucity of evidence for defining the optimal duration or interval for imaging surveillance. Shorter follow-up may be considered in some scenarios (eg, clinical factors). If stable, follow-up at 12 and 24 months from initial exam, then as clinically indicated. For changing morphology, reassess using lexicon descriptors.

***MRI with contrast has higher specificity for solid lesions, and cystic lesions with solid component(s).

****Not due to other malignant or non-malignant etiologies; specifically, must consider other etiologies of ascites in categories 1–2.

**FIGURE 4.16** O-RADS Ultrasound Risk Stratification and Management System. (Published with permission from the American College of Radiology®. Current information on O-RADS is available on www.acr.org.)

## Risk Stratification Based on MRI

MRI as a secondary imaging modality has the added benefit of further characterizing ovarian and adnexal lesions, which are sonographically indeterminate, with improved sensitivity and specificity for the detection of malignant adnexal lesions. O-RADS-MRI categorizes the adnexal lesions into categories with different levels of risk assessment for malignancy. Similar to O-RADS Ultrasound, O-RADS MRI guidelines for adnexal findings include management recommendations.

# IMAGING FOR COMPLICATIONS OF PELVIC SURGERY

Surgery is the mainstay of treatment for most gynecologic diseases. Many gynecological surgeries are associated with specific complications and general complications, which can be seen in almost any postsurgical patient undergoing gynecologic surgery. Abdominopelvic CT is the imaging modality of choice for the evaluation of most postsurgical complications, particularly in the early postoperative period.

Complications typically seen in the early postoperative period include hemorrhage, infection, wound dehiscence, and injury to adjacent bowel or urinary tract. The most common postsurgical complication is hemorrhage or hematoma, for which CT imaging is the study of choice and will demonstrate higher CT attenuation (70-90 HU). CT can identify active extravasation with the administration of intravenous contrast. Infection or abscess, which may occur in the setting of hematoma or visceral injury, will appear as a rim-enhancing, air-containing collection. CT can also evaluate if bowel perforation or fistulous connections with adjacent structures are present. Please note that imaging alone is often unable to include or exclude the presence of infection, and clinical context is of utmost importance. Other postoperative events that can be identified by CT include identification of postsurgical fluid collections including seromas that appear as simple, thin-walled, fluid attenuating

collections; lymphoceles; and peritoneal inclusion cysts that will appear radiographically as a loculated fluid collection encasing the ovary.

The small bowel and rectosigmoid colon are at risk for potential injury due to their location adjacent to the reproductive organs, and the finding of intraperitoneal free air or extravasation of oral contrast indicates a bowel injury. Injury to the adjacent urinary bladder or ureters can be another postoperative concern, and CT cystogram can be ordered for the evaluation of urine extravasation in the setting of a bladder injury. CT urogram is preferred for evaluation of suspected ureterovesicular injuries.

Potential delayed complications include but are not limited to adhesions, bowel obstruction, and pelvic floor dysfunction. Fistula development can be an early or late complication. MRI is the preferred imaging modality for complex fistulous tract evaluation given multiplanar capabilities, which appear as small T2 hyperintense tracts with enhancing inflammatory walls connecting two hollow organs or an abscess cavity to a hollow organ. Similarly, a suspected wound dehiscence can be evaluated by MRI.

# KEY POINTS

- US and CT are the preferred imaging modalities for the assessment of acute pelvic pain and/or bleeding.
- MRI is the preferred method for assessment of deep infiltrating endometriosis and fibroid mapping for surgical/procedural planning. Additionally, MRI is helpful for assessment of müllerian anomalies.
- Ultrasound is the first-line imaging modality for evaluation of an ovarian or adnexal lesion. O-RADS ultrasound (O-RADS US) categorizes the adnexal lesions into categories with different levels of risk assessment for malignancy based on predetermined US findings. ORADS-US also recommends further assessment with MRI and/or referrals for management based on the risk assessment and imaging findings.

- MRI as a secondary imaging modality has the added benefit of further characterizing ovarian and adnexal lesions that are sonographically indeterminate, with improved sensitivity and specificity for the detection of malignant adnexal lesions. ORADS-MRI triages the adnexal lesions into categories with different levels of risk assessment for malignancy based on predetermined MRI findings.
- Many gynecological malignancies demonstrate FDG avidity and functional information provided by the FDG PET with associated hybrid anatomical information on PET/CT and on PET/MRI improves diagnostic accuracy.
- MRI is the preferred imaging technique for the assessment and diagnosis of cystic lesions of the lower genitourinary tract including urethral diverticulum, Gartner duct cyst, Skene duct cyst, and Bartholin gland cyst.
- Abdominopelvic CT is the imaging modality of choice for the evaluation of postsurgical complications, particularly in the early postoperative period.
- CT urogram and CT cystogram are preferred modalities for ureterovesicular injury evaluation following surgery.

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# CHAPTER 5

# PATIENT POSITIONING FOR PELVIC SURGERY

Kimberly Kenton and Margaret G. Mueller

**Incidence of Nerve Injury**
Lower Limb
Upper Limb
**Basic Neural Anatomy and Relationship to Injury**
Seddon's Classification of Nerve Injury
Risk Factors
**Lower Limb**
Lumbosacral Plexus Anatomy
Proper Positioning to Prevent Nerve Injury
Clinical Implications and Management
**Upper Limb**
Brachial Plexus Anatomy
Proper Positioning to Prevent Nerve Image
Clinical Implications and Management

Peripheral neuropathies during gynecologic surgery tend to be transient and self-limited, with the majority of patients experiencing complete symptom resolution. However, long-term motor and sensory impairment may result in adverse quality of life, so it is

important for gynecologic surgeons to understand types of and risks for lower and upper limb nerve injury to minimize long-term consequences. Most peripheral nerve injuries at the time of gynecologic surgery are associated with patient positioning (upper and lower limbs), stirrups, use of self-retraining retractors, low transverse incisions or port sites, and long operating times.

The lumbosacral and brachial plexuses are susceptible to compression or stretch of a peripheral nerve and its vascular supply, which typically result in a mild injury to the myelin sheath, creating a local conduction block. This causes a temporary loss of nerve function with complete recovery within hours to months of the injury. Sometimes a more severe nerve injury occurs, in which the axon itself is injured but the connective tissue framework is intact. In these cases, the axon can regenerate over time. Rarely, a pelvic nerve is transected, disrupting the axon and connective tissue and resulting in the most severe nerve injury with the worst prognosis. Knowing these types of nerve injury and the associated prognosis for recovery is important for counseling patients and planning neurophysiologic consultation.

Every attempt should be made to avoid nerve injuries, as many are preventable. Therefore, if gynecologic surgeons have a solid understanding of the anatomy of the brachial and lumbosacral plexuses, the mechanisms by which nerve injuries occur, and common risk factors, they will be able to minimize the incidence of injury and hasten recovery.

# INCIDENCE OF NERVE INJURY

Incidence of peripheral nerve injury at the time of gynecologic surgery is <2%. Injuries to the nerves of the lumbosacral plexus are more common (1.9%) than those to the brachial plexus or upper limb peripheral nerves (0.16%).

## Lower Limb

At one single institution, a prospective series of over 600 women undergoing gynecologic surgery indicated that the incidence of

peripheral nerve injury was 1.8% (95% CI 1.0-3.2). The majority of procedures in this series were performed through a vaginal route (43%) followed by a laparoscopic route (26%) and laparotomy (22%). Most patients were positioned in stirrups: 46% with support boots and 47% in candy cane stirrups. Although there was not a significant difference in the incidence of neuropathy by type of stirrup, twice as many women positioned in candy cane stirrups experienced peripheral nerve injury compared to those in booted stirrups. Fortunately, 91% patients with a nerve injury had complete resolution of their symptoms within a median of 32 days (range 1 day to 6 months). Nine of the 11 nerve injuries resolved with no treatment; one patient required a single trigger point injection; and one patient underwent physical therapy.

## Upper Limb

A single-site, retrospective chart review of 3200 advanced laparoscopic procedures reported five upper limb nerve injuries over 10 years for an incidence of 0.16%. In a 2010 review of the literature, Shveiky et al. found 24 published cases of brachial plexus injury after laparoscopic surgery. Most patients recovered over the course of 1 week to 9 months. Although brachial plexus and upper limb neuropathies are uncommon and mostly self-limited, they result in significant anesthesia malpractice claims. A review of the American Society of Anesthesiologists Closed Claims Study Database found that 15% of claims were for anesthesia-related nerve injuries. In women, nearly half (46%) of closed claims were upper limb injuries: 29% were brachial plexus and 17% were ulnar. This review also demonstrated that use of shoulder braces was associated with brachial plexus injury and 40% of claims were paid regardless of whether negligence was proven.

# BASIC NEURAL ANATOMY AND RELATIONSHIP TO INJURY

A peripheral nerve (**FIG. 5.1**) is the structure used by efferent (motor) and afferent (sensory) axons to transmit information in the peripheral nervous system to and from the central nervous system. Understanding the basic structure of a peripheral nerve allows surgeons to identify potential sites and mechanisms of injury. This knowledge should be applied to surgical planning and patient positioning to minimize neuropathy. Each nerve fiber, or axon, with its associated Schwann cells, is embedded in the *endoneurium*, which is a loose, collagenous matrix with large extracellular spaces. Groups of nerve fibers are arranged into fascicles and surrounded by the *perineurium*, a dense, mechanically strong connective tissue sheath that protects individual fibers from external trauma. Groups of fascicles are embedded in the *epineurium*, a loose connective tissue, which provides a cushion of protection during movements and compression. Importantly, the epineurium also contains the vascular supply, which crosses the perineurium to supply the nerve fiber itself. Finally, a superficial layer or adventitia surrounds the epineurium and is important in allowing natural movement of the nerve.

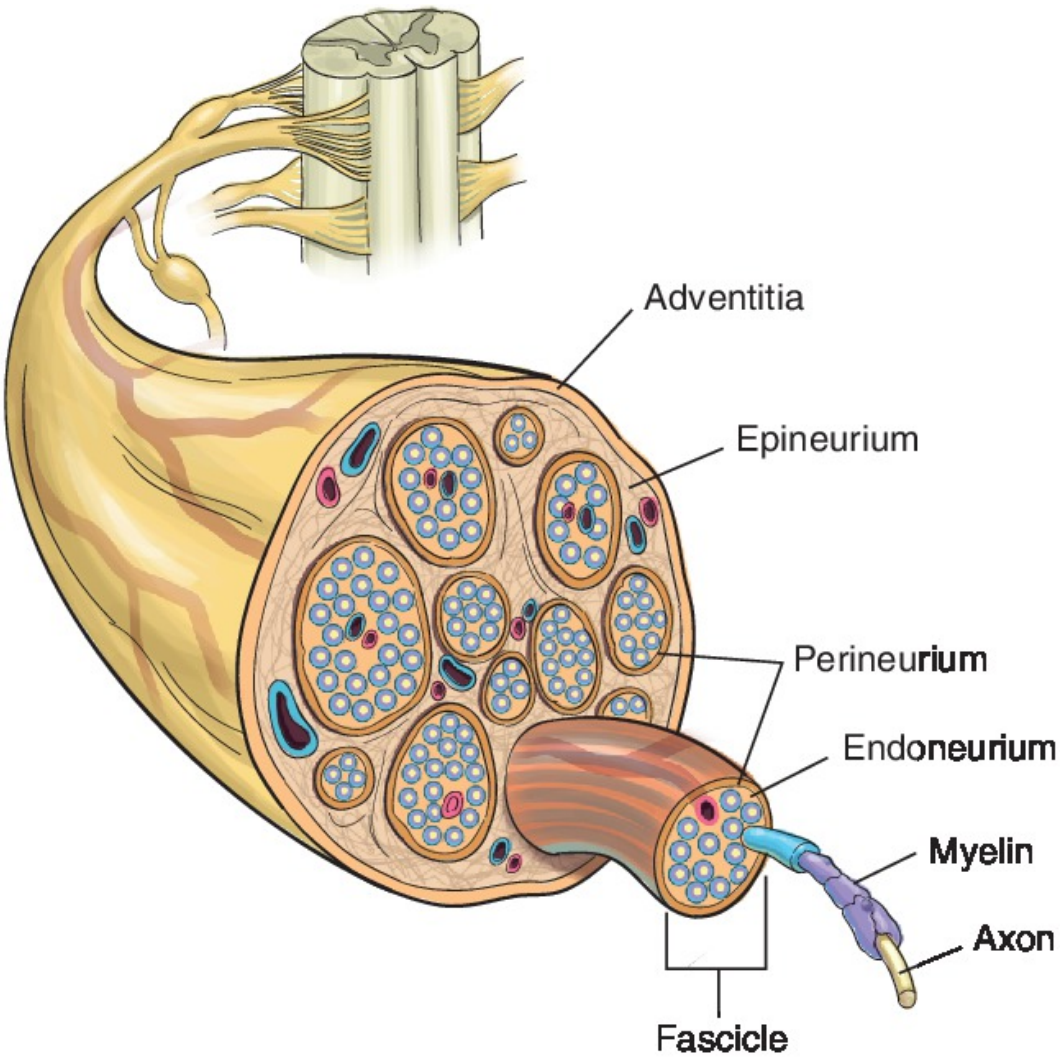


**FIGURE 5.1** Peripheral nerve. Each nerve fiber, or axon, is embedded in the *endoneurium*, and then groups of nerve fibers are arranged into fascicles and surrounded by the *perineurium.* Most superficially, groups of fascicles are embedded in the *epineurium*, which provides a cushion of protection during movements and compression. The epineurium also contains the vascular supply, which crosses the perineurium to supply the

nerve fiber itself. Finally, a superficial layer or adventitia surrounds the epineurium and is important in allowing natural movement of the nerve.

The arrangement of nerve fibers into fascicles, surrounded by loose connective tissue, and the elasticity of the perineurium have important implications for the protection and resilience of peripheral nerves. Namely, they help make peripheral nerves resistant to both *compression* and *stretch* injury. Nerves with one or two large fascicles and a thin epineurium are more vulnerable to compression injury compared to nerves with many smaller fascicles and more epineurium. When a nerve injury does occur from compression, both the amount of pressure and duration of compression have important implications in nerve recovery. Locally applied pressure of 80 mm Hg results in complete vascular obstruction and ischemia in the compressed nerve segment, and when the pressure or ischemia is sustained for 70 minutes, it results in irreversible nerve injury. Compression at lower pressures can also result in irreversible nerve injury from both ischemia and mechanical deformation of the neural structure. These figures can be useful in helping gynecologic surgeons prevent peripheral nerve injuries. For example, if a surgery is prolonged for >2 hours, it may be beneficial to briefly adjust self-retaining retractors or stirrups to allow for reperfusion.

Similarly, when a peripheral nerve is *stretched*, the arrangement of nerve fibers into fascicles embedded in the epineurium allows for natural movement of the fibers. For example, when you reach out and stretch to grab something, nerves get stretched, but the nerve fibers are not damaged secondary to this telescoping effect. However, when a nerve is stretched beyond 15% of its length, the vascular supply to the nerve fibers is compromised, resulting in irreversible nerve injury.

The degree of nerve injury can be classified according to its severity using Seddon's classification, which helps the surgeon anticipate the patient's prognosis and recovery. The different

degrees of peripheral nerve injury will result in a variety of signs and symptoms ranging from muscle weakness to sensory alterations, pain, and paresthesias to absent reflexes. The severity of nerve injury is related to the degree and duration of ischemia from compression or stretch of the nerve.

# Seddon's Classification of Nerve Injury

## *Neurapraxia*

Neurapraxia, or a local conduction block, is the mildest form of nerve injury. The nerve sustains stretching or compression that results in transient nerve ischemia and leads to a focal conduction block across the affected portion of the nerve. There is no disruption to the axons or Schwann cells. This type of injury affects motor fibers more than it does sensory fibers. The transient conduction block often resolves within a few minutes (similar to when your foot "falls asleep"); however, longer periods of compression or stretch may result in edema and demyelination, which can block impulse conduction. Neurapraxic injuries may take days to up to 6 weeks to resolve.

## *Axonotmesis*

Prolonged or excessive compression or stretch can result in actual disruption to the axons while preserving the supporting Schwann cell. This results in an axonal injury, and wallerian degeneration begins within 24-36 hours of injury. It affects motor, sensory, and autonomic functions that can take weeks to months to resolve. Even though the axon is disrupted, regeneration is usually complete, because the supporting Schwann cell remains intact. Axons grow at a rate of 1-2 mm/d, so if the site of injury is known, the surgeon can anticipate and counsel the patient regarding recovery time.

## *Neurotmesis*

Neurotmesis is the most severe form of nerve injury resulting in complete neural separation, including disruption of the axon, Schwann cell, and connective tissue elements. It typically results from complete transection of the nerve. With the axons lacking their supporting structures, they cannot regrow without surgical intervention to reconnect the connective tissue–supporting structures.

# Risk Factors

Fortunately, many risk factors for peripheral nerve injury during gynecologic surgery are modifiable and related to the type of surgery and position of the patient. In the largest prospective study of women undergoing gynecologic surgery, the authors did not find an association between patient's age, body mass index, Charleston Comorbidity Index, smoking history, peripheral vascular disease, neurologic disease, lumbar spine disease, or operating room time and peripheral nerve injury. However, it should be noted that the incidence of nerve injury in this cohort was low, increasing the likelihood of a type II error. In contrast, larger database studies using American College of Surgeons National Surgical Quality Improvement Program suggest that smokers are at increased risk and that minimally invasive techniques and shorter operating room times are associated with reduced risk of peripheral nerve injury.

Patient positioning is an important modifiable risk factor for peripheral nerve injury. Patients positioned in stirrups in dorsal lithotomy are at increased risk of injury to the lumbosacral plexus nerves. One large retrospective study showed a 100-fold increase in nerve injury with each hour in dorsal lithotomy position. Similarly, prospective studies showed that dorsal lithotomy >2 hours was associated with increase in nerve injury. Likewise, several studies report an association between brachial plexus injury and steep Trendelenburg, shoulder braces, and arms extended >90° during laparoscopic and/or robotic surgery. In a 2010 review of the literature, Shveiky et al. found 24 published cases of brachial plexus injury after laparoscopic surgery. Average operating room time was

215 minutes; Trendelenburg positioning was used in all and 38% used shoulder braces.

# LOWER LIMB

## Lumbosacral Plexus Anatomy

The lumbosacral plexus innervates the lower limbs, lower abdominal wall, and perineum.

The lumbar plexus consists of the anterior branches of the first four lumbar spinal nerves (L1-L4) with contributions from the 12th thoracic nerve. It is formed lateral to the intervertebral foramina and passes through the psoas major muscle. The anterior ramus of L1 splits into three branches: two form the iliohypogastric and ilioinguinal nerves and the third merges with anterior ramus of L2 to form the genitofemoral nerve. The ventral ramus of L2 divides into four branches with contributions to the genitofemoral, lateral femoral cutaneous, obturator, and femoral nerves. The ventral ramus of L3 combines with L2 to contributes to the lateral femoral cutaneous, femoral, and obturator nerves. The ventral ramus of L4 divides into three branches, which contribute to the obturator and femoral nerves and combine with L5 to form the lumbosacral trunk. The lumbosacral trunk emerges medial to the psoas muscle and combines with the anterior rami of the first three sacral nerves to form the sacral plexus (which lies in front of the piriformis muscle) and pudendal plexus.

The sacral plexus innervates the lower limbs and pelvic girdle muscles, and the pelvic plexus innervates the perineum and pelvic viscera. The anterior rami of S1-S3 and the lumbosacral trunk form the sciatic nerve, which branches in the leg to the tibial and common peroneal nerves. The sacral plexus also provides branches to the pelvic girdle muscles.

### *Nerves, Nerve Roots, and Points of Vulnerability* (TABLE 5.1)

# TABLE 5.1
# Lumbosacral Nerves, Nerve Roots, and Point of Vulnerability

| NERVE | ROOT | FIBER TYPE | INNERVATION | SYMPTOMS | VULNERABILITY |
|---|---|---|---|---|---|
| Ilioinguinal<br>Iliohypogastric | L1 | Afferent | Internal oblique<br>Transversus abdominis<br>Labia majora | Burning pain, paresthesia at incision radiates | Low transverse incisions<br>Lower quadrant ports<br>Self-retaining retractors |
| Lateral femoral cutaneous | L2-L4 | Afferent | Lateral thigh | Pain and paresthesia anterior lateral thigh to knee | Hip flexion<br>Self-retaining retractors |
| Femoral | L2-L4 | Afferent<br>Efferent | Quadriceps<br>Anterior thigh<br>Medial leg | Unable to<br>• Flex hip<br>• Extend knee<br>• Adduct thigh<br>Hypoesthesia anterior thigh<br>Absent patellar reflex | Self-retaining retractors<br>Excessive hip flexion |
| Obturator | L2-L4 | Afferent<br>Efferent | Adductors<br>Medial thigh | Unable to adduct thigh<br>Hypoesthesia medial thigh | Prolonged hip flexion<br>Retropubic dissection |
| Sciatic | L4-S3 | Afferent<br>Efferent | Hamstrings<br>Posterior thigh<br>Lateral leg | Pain down posterior leg<br>Unable to<br>• Extend thigh<br>• Flex leg<br>Hypoesthesia of the posterior thigh, calf, and sole of the foot<br>Absent Achilles reflex | Hyperflexion of the hip<br>Extension of the leg |
| Common peroneal | L4-S2 | Afferent<br>Efferent | Anterior leg | Footdrop<br>Unable to dorsiflex foot<br>Hypoesthesia of the lateral leg and foot | Extension and rotation of the hip<br>Extension of the knee<br>Lateral pressure of the fibula |
| Pudendal | S2-S4 | Afferent<br>Efferent | Striated urethral sphincter<br>External anal sphincter<br>Clitoris, perineal and perianal skin | Stress incontinence<br>Fecal incontinence<br>Pelvic pain | Vaginal childbirth |

## Ilioinguinal/Iliohypogastric Nerves

The iliohypogastric and ilioinguinal nerves are formed from the anterior rami of L1 nerve roots and contain only afferent or sensory nerve fibers. The nerves emerge from the upper, lateral border of the psoas muscle and then course laterally over the quadratus lumborum. Near the iliac crest, they perforate the transversus abdominis and course medially and inferiorly to the internal oblique muscles. In cadaveric studies, the ilioinguinal nerve emerges through the internal oblique muscle 2.5 cm medial and 2.0 cm inferior to the anterior superior iliac spine. Therefore, low transverse incisions and laparoscopic trocars placed inferior to the anterior superior iliac spine may result in entrapment or laceration of these

nerves. Similarly, low transverse incisions that begin 2 cm above the pubic symphysis may compromise the iliohypogastric nerve if the incision extends more than 3.5 cm laterally. Care should be taken to not place the fascial closure suture lateral to the angle of the fascial incision to minimize entrapping the nerves.

Iliohypogastric/ilioinguinal nerve entrapment is diagnosed by a triad of sharp, burning pain at the incision site that radiates to the suprapubic, labial, or thigh areas; paresthesias; and pain relief after injection with local anesthetic. Single or repeat injections of a long-acting local anesthetic, such as 0.25% bupivacaine, frequently result in complete symptom resolution; however, surgical intervention with stitch removal or neurolysis is sometimes necessary. A retrospective cohort study of 317 women undergoing gynecologic laparoscopy with lower abdominal ports reported a 5% risk of clinically significant injury to the iliohypogastric and/or ilioinguinal nerves when the fascial defect was closed. There were no nerve injuries in the 173 patients who did not have fascial closure. Nearly all reported sharp, burning pain localized to the port site within 1 day of surgery, which was successfully treated with nerve blocks or lidocaine patches followed by suture release. Other medical therapies for entrapment neuropathies include physical therapy with scar mobilization, short doses of oral steroids to decrease inflammation around the nerve, and neuropathic pain medication such as gabapentin or low doses of tricyclic antidepressants.

## Lateral Femoral Cutaneous

The lateral femoral cutaneous nerve originates from L2 to L4 nerve roots and passes along the outer edge of the psoas muscle and then below the lateral inguinal ligament close to the anterior superior iliac spine. It provides sensation to the lateral thigh. The incidence of lateral femoral cutaneous nerve compression with prolonged hip flexion while in stirrups is 0.4%. It is also subject to compression from long, self-retraining, retractor blades as the nerve runs through the psoas muscle. Patients with lateral femoral cutaneous nerve injury present with meralgia paresthetica or burning pain, paresthesia, and hypoesthesia over the anterior and lateral thigh down to the knee.

## Femoral

The femoral nerve arises from the anterior divisions of L2-L4 as the largest branch of the lumbar plexus. It emerges from the lateral boarder of the psoas muscle and enters the thigh below the inguinal ligament where it divides into motor and sensory branches. The femoral nerve innervates the quadriceps muscles and provides sensory branches to the anterior thigh and medial leg.

The femoral nerve is susceptible to compression injury as it runs in the psoas muscle and as it exits the pelvis under the ilioinguinal ligament. Long lateral retractor blades can rest on the psoas muscle and compress the femoral nerve as it runs in the psoas muscle. Thin patients are at higher risk for similar reasons. Low transverse incisions may also result in lateral compression of psoas and nerve against bony pelvis. Older studies report the incidence of femoral nerve injury after laparotomy with self-retaining retractors to be as high as 11%.

Patients undergoing surgery with their legs in stirrups are also at risk of femoral nerve injury. The femoral nerve is subject to compression as it passes under the ilioinguinal ligament. Care should be taken to avoid excessive hip flexion, abduction, and external hip rotation in stirrups. Surgical assistants should avoid leaning against the thigh to prevent compression as well.

Patients with femoral nerve injury will have difficulty with hip flexion, knee extension, and adduction. The inability to flex at the hip results in difficulty rising from seated position, getting out of bed, or walking up stairs. Therefore, these patients are often not able to get out of bed after surgery. They can also have sensory loss or paresthesia over the anterior thigh and an absent patellar reflex.

## Obturator

The obturator nerve arises from the anterior rami of L2-L4 and then descends through the psoas and obturator internus muscles to innervate the adductor muscles in the thigh. Unlike most other lumbosacral nerve injuries, the obturator nerve is most likely to be transected or crushed in the obturator space during retroperitoneal dissection for gynecologic malignancies or endometriosis. The

obturator space is opened by applying gentle lateral retraction on the external iliac artery and vein, increasing identification of the obturator nerve. If transection of the obturator nerve is recognized during surgery, the supporting connective tissue around the nerve should be immediately repaired with a fine gauge suture to promote axonal regrowth and minimize long-term adverse effects.

The obturator nerve can also be entrapped during urogynecologic surgery such as transobturator midurethral sling placement or paravaginal defect repair. Therefore, when dissecting the retropubic space for paravaginal repair, surgeons should identify the obturator notch and neurovascular bundle before placing sutures. Finally, obturator nerve can be stretched during inappropriate placement in stirrups. Prolonged hip flexion can lead to obturator nerve stretching at the bony foramen.

Patients with obturator nerve injury are unable to adduct the thigh and may report sensory loss or paresthesias over the medial thigh. These patients often report difficulty ambulating and driving. Obturator and femoral nerve injuries can often be difficult to distinguish on physical examination; however, the patellar reflex is preserved in patients with obturator nerve injury.

## Sciatic

The sciatic nerve originates from the anterior division of L4-S3 and exits the pelvis through the greater sciatic foramen to enter the gluteal region. It descends on the posterior thigh where it divides into two branches at the top of the popliteal fossa: the tibial and common peroneal nerves. The sciatic nerve supplies the hamstring muscles of the thigh and motor and sensory to the leg.

The sciatic nerve is fixed between the sciatic notch and fibular head, leaving it vulnerable to stretch injury with hyperflexion at the hip in stirrups. Sciatic nerve stretch is further exacerbated by extension at the knee combined with flexion at the hip as can be found in candy cane stirrups and high lithotomy. The sciatic nerve is rarely injured during laparotomy but may become entrapped in sutures placed during sacroiliac fossa hemorrhage.

Sciatic nerve injury most often presents with sensory symptoms. When the sciatic nerve is entrapped or compressed, patients report

severe pain radiating down the posterior leg, which is often associated with hamstring weakness and absent Achilles reflex. These patients often have hypoesthesia or paresthesia over the posterior aspect of the thigh, calf, and sole of the foot and weakness with hip extension and knee flexion.

## Common Peroneal

Common peroneal nerve is one of the two terminal divisions of the sciatic nerve and is the most frequently injured nerve when patients are positioned in stirrups. It passes anteriorly around the fibular head to innervate the anterior compartment of the leg, which contains the muscles responsible for dorsiflexion and eversion of the foot. It also supplies sensory innervation to the lateral leg and dorsal foot.

A couple of features of the common peroneal nerve make it particularly susceptible to both stretch and compression injuries. The sciatic nerve, which branches into the common peroneal nerve, is fixed between the sciatic notch and the fibular head, which predisposes the common peroneal nerve to stretch injury related to prolonged knee flexion and excessive hip rotation in candy cane stirrups. The way the common peroneal nerve wraps around the fibular head also predisposes it to compression injuries in candy cane stirrups. Proper positioning in booted stirrups reduces this risk; however, the surgical team must ensure the lateral leg is not being compressed by the boot. The patient's heel should be firmly positioned in the back of the boot to avoid the lateral leg resting on the side of the boot. If the heel is not securely positioned in the boot, the leg may rest up the upper boot and compress the common peroneal nerve between the boot and fibular head. To prevent common peroneal nerve when positioning patients in stirrups, ensure the hips are moderately flexed and abducted, with knee flexion. Avoid hyperextension at the hip, external rotation, hyperextension at the knee, and lateral pressure on the fibular head.

Patients with a common peroneal nerve injury typically present with footdrop, which is easily diagnosed during ambulation. These patients also experience inversion and sensory loss over the lateral leg and foot.

# Pudendal

The pudendal nerve arises from the anterior roots of S2-S4 to coalesce in the pelvis just proximal to the sacrospinous ligament. It leaves the pelvis through the greater sciatic foramen only to reenter through the lesser sciatic foramen, at which point it travels along the obturator internus fascia or the Alcock canal. It eventually splits into its three terminal branches: dorsal nerve to the clitoris, which provides sensation to the clitoral area; perineal nerve, which innervates the striated urethral sphincter muscle and perineal skin; and the inferior hemorrhoidal nerve, which innervates the external anal sphincter and perianal skin.

The pudendal nerve is susceptible to compression and stretch injury as it travels through the Alcock canal in the pelvis as well as nerve entrapment. A common etiology for pudendal neuropathy is vaginal childbirth. Studies have shown neurophysiologic evidence of pudendal nerve injury in the external anal sphincter and striated urethral sphincter after vaginal childbirth. Similarly, studies have demonstrated neurophysiologic evidence of pudendal neuropathy in patients with stress urinary incontinence and fecal incontinence. Anterior vaginal wall dissection at the time of prolapse and incontinence surgery can also result in injury to the branches of the pudendal nerve innervating the urethra and anterior vaginal wall. Patients with pudendal nerve injury may present with stress urinary and/or fecal incontinence.

The pudendal nerve can also become entrapped resulting in pudendal neuralgia. Pudendal neuralgia is neuropathic pain in the distribution of the pudendal nerve. Diagnosis of pudendal neuralgia is facilitated by using the Nantes criteria, which illustrate five characteristics of the syndrome including pain along the distribution of the pudendal nerve, pain while sitting, pain that does not wake patients at night, absence of sensory loss, and resolution of symptoms with the administration of local anesthesia. Areas of the nerve that are particularly vulnerable to entrapment injuries include the region between the sacrospinous and sacrotuberous ligaments, pudendal canal, and inferior surface of the pubic ramus. Classically, this syndrome can occur following sacrospinous ligament suspension when a portion of the nerve is entrapped with the

suspension suture. While the mainstay in managing pudendal neuralgia is conservative management with injection of local anesthesia, occasionally, neurolysis is required to resolve symptoms.

# Proper Positioning to Prevent Nerve Injury

Many lower limb peripheral nerve injuries can be minimized or prevented by careful placement of the patient's limbs in stirrups while in dorsal lithotomy. The exact positioning will depend on the type of surgery to be performed, for example, low lithotomy for laparoscopic vs high lithotomy for vaginal routes of access; however, certain principles regarding leg positioning should be followed. We recommend positioning the patients' limbs in stirrups before the induction of anesthesia to ensure patient comfort, minimize undo neural compression, and minimize intraoperative nerve injury.

## *Booted Stirrups*

When using booted stirrups (**FIG. 5.2**), the weight of the patient's heel should fall on the proximal part of the foot support to prevent compression of the common peroneal nerve between the fibular head and boot. Ideally, the hip should be flexed at an angle between 90° and 170° to the patient's trunk. Greater flexion of the hip (a smaller angle) may result in stretch of the obturator nerve, while extension of the hip or hip-trunk angle >180° may put strain on the lumbar spine. Too much hip flexion can cause compression of the femoral nerve under the inguinal ligament or stretch of the sciatic nerve where it is fixed at the sciatic notch. The knee should be flexed, so the angle between the calf and thigh is 90°-120°, and there should not be more than 90° between the inner thighs to minimize obturator nerve stretch. Finally, there should be minimal external rotation of hips.

**FIGURE 5.2** Booted stirrup. Hip flexed at a 170° angle to the patient's trunk and knee flexed, so the angle between the calf and thigh is 90°-120°.

## *Candy Cane Stirrups*

Candy cane stirrups (**FIG. 5.3**) are typically reserved for high lithotomy positioning for vaginal surgery; however, similar principles pertain to positioning of the lower limbs in candy cane and booted stirrups. Candy cane stirrups provide little support to the lower limbs compared to booted stirrups, and their use is associated with increased risk of lower limb nerve injury after gynecologic surgery. The lack of support increases the risk of hip abduction >90° and external rotation. When candy cane stirrups are used, the surgeon should ensure that the foot is firmly placed in the holder and elevated to prevent hyperflexion of the hip, which can result in compression of the femoral nerve and stretch of the sciatic nerve. Care should also

be taken to prevent the lateral leg from resting upon the support pole and compressing the common peroneal nerve where it wraps around the fibular head. One large study found that the incidence of lower limb nerve injury was twice as high in patients who underwent surgery in the high lithotomy position when their legs were positioned in candy cane stirrups (2.6%) compared to booted stirrups (1.3%), although this difference did not reach statistical significance. More recently, investigators at the University of Iowa reviewed 2449 cases of patients who underwent benign gynecologic surgery lasting longer that 1 hour. Postoperative neuropathy was uncommon in both groups but occurred significantly more often in patients positioned in candy cane stirrups (3.4%, 95% CI 2.1%-5.2%) than those in booted stirrups (1.6%, 95% CI 1.1%-2.3%) ($p$ = .008).

A

B

C

**FIGURE 5.3** Candy cane stirrup. **A.** When properly positioned in candy cane stirrups, the foot should be firmly placed in the holder to prevent hyperflexion of the hip. **B.** The lateral leg should not rest on the support pole, as is

shown here. **C.** The knee should not be extended, as is shown here.

## *Retractors*

During laparotomy, surgeons should use the shortest self-retaining retractor blades necessary to minimize compression of the femoral nerve under the retractor and psoas muscle. Extremely thin patients are at higher risk for compression of femoral and/or lateral femoral cutaneous nerves. Likewise, surgeons should ensure adequate exposure of the fascial edges during fascial closure after low transverse incisions. Placing sutures well beyond the lateral fascial margins can predispose patients to entrapment of the ilioinguinal and/or iliohypogastric nerves.

# Clinical Implications and Management

Most lower limb peripheral nerve injuries sustained during gynecologic surgery are neurapraxic injuries, resolve spontaneously within a few weeks to months, and do not require further evaluation. Regardless, all patients with a suspected peripheral nerve injury should undergo a thorough history and physical examination with special attention to the neuromuscular components. The history should focus on the patient's sensory and motor symptoms, including motor dysfunction, pain, paresthesia, or hypoesthesia. Physical examination should include objective assessment of motor strength in each muscle group of the lower limb and sensory evaluation in various nerve distributions. Lower limb reflexes should be tested for presence and symmetry, and surgeons should evaluate the patient's gait. Patients who experience motor dysfunction or difficulty with ambulation may benefit from early physical therapy and supportive care. If a more severe nerve injury is suspected or a patient's symptoms do not improve within 3-4 weeks, electrodiagnostic consultation should be considered. Electrodiagnostic studies can help estimate recovery time and prognosis, which surgeons can use to counsel patients and set

realistic expectations. While neurapraxic nerve injuries have a good prognosis for quick recovery, some nerve injuries have components of neurapraxia and axonotmesis. While the neurapraxic component resolves quickly, the axonal component takes longer to recover owing to the time required for wallerian degeneration and axonal regeneration. These patients often recover some function quickly as the local conduction block and demyelination resolve but do not experience complete recovery for many months as axons regenerate. Similarly, electrodiagnostic studies done too quickly after a peripheral nerve injury cannot differentiate neurapraxia from axonotmesis. Immediately after injury, both result in electrodiagnostic findings consistent with a local conduction block and cannot be distinguished from each other. It takes ~10-30 days for wallerian degeneration to occur and yield electrodiagnostic findings consistent with axonotmesis. Therefore, electrodiagnostic studies done too early after an injury can underestimate the severity of lesion. Generally, these studies should not be done before 3-4 weeks after surgery/injury.

# UPPER LIMB

## Brachial Plexus Anatomy

The brachial plexus is responsible for the efferent (motor) and afferent (sensory) innervation of the upper limb and is formed by the anterior branches of the last four cervical (C5-C8) and the first thoracic (T1) nerve roots. The spinal nerve roots are arranged into trunks, which split into divisions and cords, and finally the peripheral nerves of the upper limb and shoulder. Within the plexus, there are three trunks: the superior trunk from the anterior rami of C5 and C6, the middle trunk from the anterior rami of C7, and the lower trunk from the anterior rami of C8 and T1. Each of the trunks split into anterior and posterior divisions, which combine to create the three cords, which are named from their position around the axillary artery below the clavicle: the lateral cord from the anterior division of the superior and middle trunk, the medial cord from the anterior division of the lower trunk, and the posterior cord from the posterior divisions

of all three trunks. The five-main upper limb peripheral nerves originate from these brachial plexus cords. The lateral cord gives rise to the musculocutaneous nerve and portions of the median nerve; the medial cord gives rise to portions of the median nerve, the ulnar nerve; the posterior cord gives rise to the radial and axillary nerves. Several anatomic features of the brachial plexus make these nerves and nerve roots vulnerable to stretch and compression injuries. The brachial plexus lies in the posterior triangle of the neck in the angle between the scalene muscles.

## *Nerves, Nerve Roots, and Points of Vulnerability* (TABLE 5.2)

### TABLE 5.2
### Brachial Plexus Nerves, Nerve Roots, and Point of Vulnerability

| NERVE | ROOT | FIBER TYPE | INNERVATION | SYMPTOMS | VULNERABILITY |
|---|---|---|---|---|---|
| Ulnar | C8-T1 | Afferent<br>Efferent | Forearm flexors<br>Intrinsic hand muscles for flexion, abduction, and adduction of the finger<br>Sensation to medial 1.5 fingers | Weakened finger abduction and adduction<br>Claw hand<br>Unable to make a fist<br>Hypoesthesia and paresthesia of the medial 1.5 finger | Compression against the arm board or operating table |
| Median | C6-C8, T1 | Afferent<br>Efferent | Anterior forearm<br>Intrinsic hand muscles—thumb and lateral 2 fingers | Weak flexion of the wrist and finger<br>Weak thumb<br>Inability to make "O" with thumb and index finger<br>Hypoesthesia of the thumb and lateral 2.5 finger | Hyperextension of elbow on arm board |
| Radial | C5-T1 | Afferent<br>Efferent | Forearm extensors<br>Posterior arm<br>Sensation to posterior aspect of lateral 3.5 fingers | Weakness when abducting the thumb, inability to straighten fingers, wrist drop<br>Hypoesthesia of dorsal lateral 3.5 digits | Pressure on the humerus |

### Ulnar

The ulnar nerve is the main terminal branch of the medial cord (C8, T1) and passes through the olecranon groove to lie close to the medial epicondyle of the humerus. The ulnar nerve is superficially located at this point and thus susceptible to compression injury,

making ulnar neuropathy the most common upper limb neuropathy from surgical positioning.

The ulnar nerve provides efferent fibers to some flexor muscles in the forearm and to the intrinsic hand muscles that control flexion, abduction, and adduction of the fingers and afferent fibers to the medial 1.5 fingers. The ulnar nerve provides no sensory innervation to the arm.

The ulnar nerve is subject to compression against arm boards or the operating table at medial epicondyle where it is protected only by skin and fascia. The ulnar nerve is particularly vulnerable if the arm is pronated on the arm board or supinated and tucked at the patient's side with inadequate padding at the elbow. Flexion of the elbow across the chest predisposes the ulnar nerve to stretch around the medial epicondyle.

Patients with ulnar nerve injury cannot make a fist and present with weakened abduction and adduction of the fingers, resulting in the clinical phenomenon known as "claw hand." Sensory loss and paresthesias to the medial 1.5 fingers are also common.

## Median

The median nerve is formed from spinal nerve fibers from the lateral and medial cords of the brachial plexus (C6-C8, T1). It provides no innervation to the upper arm and enters the forearm through the antecubital fossa. The median nerve provides innervation to most muscles in the anterior forearm and the intrinsic muscles of hand acting on thumb and lateral two fingers.

The most common mechanism of median nerve injury in gynecologic surgery is stretch associated with prolonged hyperextension of the elbow, such as if the patient's arm slips off the arm board.

Patients with median nerve injury will often have weak flexion of the wrist and fingers, weakness in all actions of the thumb, and an inability to make an "O" with the thumb and forefinger. Sensory loss across the thumb and lateral 2.5 digits is also common.

## Radial

The radial nerve lies in the spiral groove of the humerus and provides motor innervation to the extensor muscles of the wrist and fingers and sensory innervation to the posterior aspect of the lateral 3.5 fingers. It is the largest branch of posterior cord and formed from C5 to T1 fibers. The radial nerve primarily innervates the posterior arm and forearm extensor muscles and the skin overlying these areas. Pressure on the humerus during surgery may lead to compression of the radial nerve between the nerve and operating table.

Radial nerve injury leads to weakness in the wrist extensor muscles and to sensory loss or paresthesias over the dorsal lateral 3.5 digits. Patients will have weakness when abducting the thumb, inability to straighten out fingers, and wrist drop.

## Plexus Injury

The superficial location of the brachial plexus in the axilla and its firm proximal attachment to the vertebra and prevertebral fascia and distal attachment to the axillary fascia make the plexus itself vulnerable to both compression and stretch injury during gynecologic surgery. The proximity of the plexus to the mobile bony structures including the clavicle, first rib, humerus, and coracoid process also increase its vulnerability.

Overabduction, external rotation, and posterior shoulder displacement can stretch the brachial plexus. Shoulder braces placed too medially can also result in compression.

Stretch injury during laparoscopy and steep Trendelenburg is the most common mechanism of brachial plexus injury. The plexus is vulnerable to stretch from hyperabduction of the arms (upper nerve roots C5-C6) or steep Trendelenburg, which stretches the lower nerve roots (C8, T1) as the patient slides cephalad. Injuries to the brachial plexus result in arm weakness, diminished reflexes, and sensory deficits. Stretch injury of the upper trunk of the brachial plexus results in Erb palsy, which is characterized by a loss of flexion at the elbow and supination of the forearm resulting in the classic “waiter’s tip deformity.” Conversely, injury to the lower roots can result in loss of the intrinsic muscles of the hand and flexors of the wrist, yielding the classic “claw hand.” Shoulder braces to prevent

patients from sliding in steep Trendelenburg are associated with increased plexus injury particularly if arms are extended. Braces should be placed directly over the acromioclavicular joint rather than more medially or laterally to avoid compression. Wristlets can also hold patients in place and contribute to stretch injury. Similarly, abducting the arm >90° stretches the plexus between the first rib and clavicle. This is worsened if the upper limb is pronated.

A small, randomized trial compared the amount of patient displacement in steep Trendelenburg using two forms of positioning —a memory foam pad and a beanbag with shoulder braces. The beanbag with shoulder braces resulted in less displacement; however, there were no significant differences in postoperative neurologic symptoms.

# Proper Positioning to Prevent Nerve Image

## *Arm Boards*

If arm boards (**FIG. 5.4**) are used, the patient's arms should not be abducted more than 90° from the body; they should be supinated or neutral to minimize pressure on ulnar groove. While some padding can be helpful, excessive padding should be minimized. Supplementary padding, such as egg crates and gel padding, have not resulted in decreased pressures but have increased interface pressure.

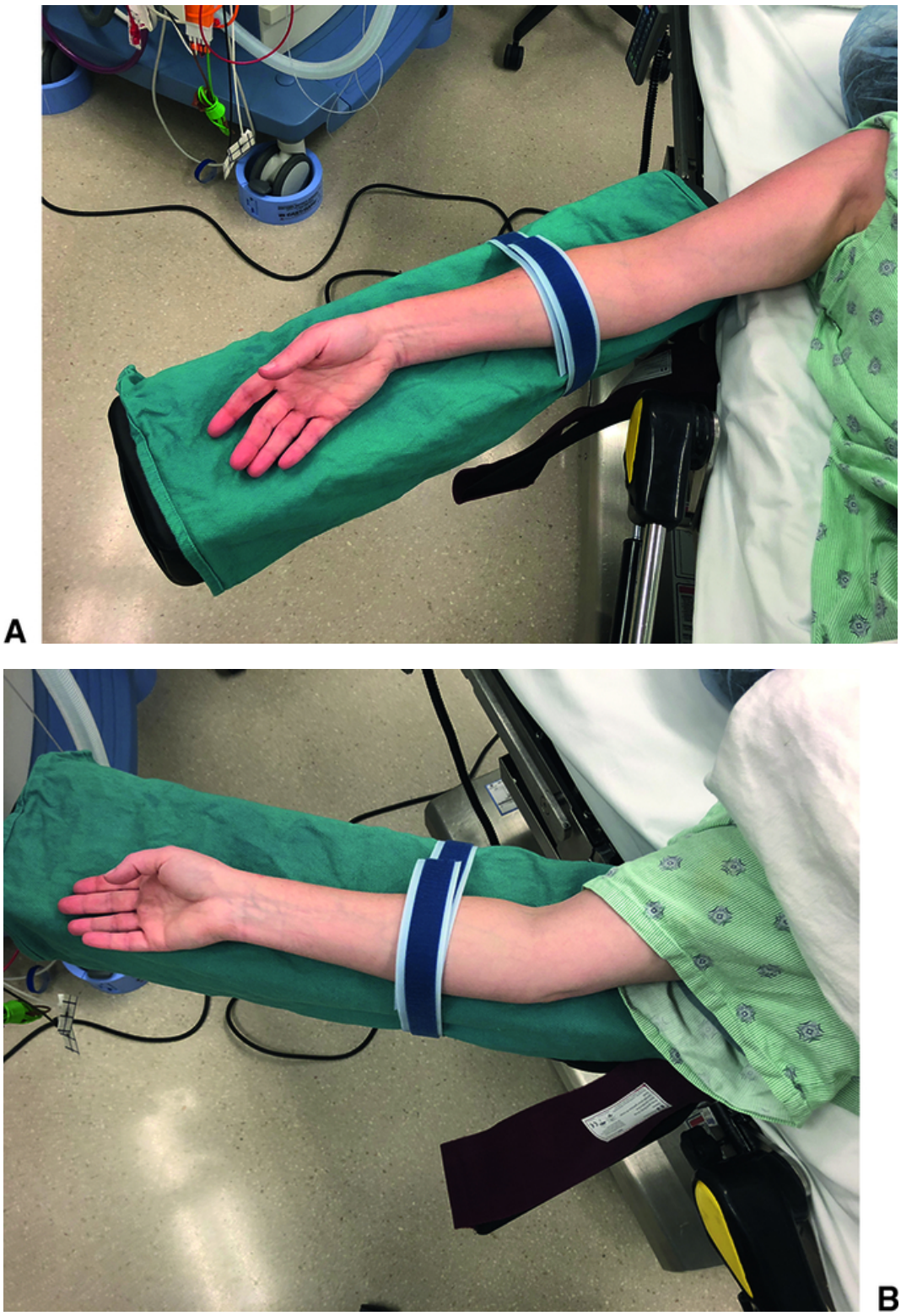


**FIGURE 5.4** Arm board. **A.** Arm should be supinated or neutral on the arm board and

abducted <90°. **B.** Arm is inappropriately positioned. It is abducted >90°.

## *Tucked*

When the patient's arms are tucked (**FIG. 5.5**) at her sides, care should be taken to ensure that the arms are positioned with the forearms and hands in neutral position. If the arm is supinated, the olecranon groove is located posteromedial and exposes the ulnar nerve to compression injury against the operating room table.

**FIGURE 5.5** Arm tucked. When arms are tucked, the arms should be positioned with the forearms and hands in neutral position.

### *Head*

Surgeons should avoid dorsal flexion or lateral extension of the patient's head during positioning. This position increases the angle between the shoulder and the head and places the brachial plexus on stretch, particularly when patients are placed in steep Trendelenburg.

## Clinical Implications and Management

Similar to lower limb peripheral nerve injuries, most upper limb neuropathies at the time of gynecologic surgery are self-limited, neurapraxic injuries that resolve without sequelae. Patients with symptoms of upper limb neuropathy should undergo thorough assessment of upper limb motor strength and sensation with reflex testing to determine the likely etiology of their symptoms. Most surgeons recommend supportive care and early physical therapy to any patients with functional impairment. Electrodiagnostic evaluation should be reserved for patients who do not experience substantial recovery in the first 3-4 weeks after surgery (consistent with neurapraxia).

## KEY POINTS

- Although peripheral nerve injury can occur despite careful positioning, a comprehensive knowledge of anatomy and proper patient positioning should minimize the risk of peripheral nerve injury during gynecologic surgery.
- While the majority of peripheral nerve injuries during gynecologic surgery are self-limited, long-term motor and sensory impairment may significantly impact quality of life; therefore, it is imperative for gynecologic surgeons to understand types of and risks for lower and upper limb nerve injury to minimize long-term consequences.

- Gynecologic surgeons should use Seddon's Classification of Nerve Injury to counsel patients about prognosis and recovery after nerve injury and to determine when and if additional electrodiagnostic testing is indicated.
  - Neurapraxia or local conduction block is the mildest form of nerve injury. Since there is no disruption to the axon or Schwann cells, neurapraxic injuries resolve within days to weeks.
  - In cases where the nerve is subject to longer periods of ischemia or deformation, the axons themselves may be injured. In axonotmesis, wallerian degeneration begins within 24-36 hours; however, since the Schwann cell remains intact, axons will regrow at a rate of 1-2 mm/d. If surgeons know the likely site of injury, she or he can estimate the time to recovery, which is usually months.
  - Neurotmesis is the most severe form of nerve injury resulting in disruption of the axon, the Schwann cell, and the supporting connective tissue. These types of nerve injuries require surgical intervention to reconnect the supporting connective tissue around the nerve.
- Most peripheral nerve injuries at the time of gynecologic surgery are associated with patient positioning (upper and lower limbs), stirrups (especially candy canes), use of self-retraining retractors, low transverse incisions or port sites, and long operating times.
- Many peripheral nerve injuries can be prevented with knowledge of these risk factors in combination with principles of nerve injury. However, if a peripheral nerve injury is observed, conservative management with close follow-up is satisfactory in mildly symptomatic patients. However, if motor deficits are identified, physical therapy is recommended.
- In patients with nerve entrapment symptoms, such as pain and paresthesias, local anesthetic agents, tricyclic antidepressants, neuropathic pain medications, and/or steroids may be considered.

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# CHAPTER 6

# SURGICAL TECHNIQUES, INSTRUMENTS, AND SUTURE

John T. Soper

**Surgical Instruments**
Scalpels
Scissors
Tissue Forceps
Needle Drivers
Tissue Clamps
Other Clamps and Instruments
Cervical Dilators
Suction Devices
Stapling Devices
Mechanical Hemostatic Devices
Harmonic Scalpel
Handheld Retractors
Fixed Retractors
**Suture**
Natural Absorbable Sutures
Natural Permanent Sutures
Synthetic Sutures

Synthetic Permanent Sutures

Metal Sutures

Surgical Needles

Surgical Knots

**Surgical Techniques**

Dissection Techniques

Elevate and Incise

Push and Spread

Rubbing/Wiping

Hydrodissection

**Exploration of Pelvic Retroperitoneum**

Dissection of the Pelvic Brim and Pararectal Space

Ligation of the Internal Iliac (Hypogastric Artery Ligation) and Uterine Arteries

Dissection of the Presacral Space

Dissection of the Space of Retzius or Retropubic Space

Dissection of the Paravesical Space

Retained Surgical Instruments

The student of gynecologic surgery should understand basic surgical instruments and basic manual surgical techniques. Coupled with a functional understanding of surgical anatomy, these are the foundation for the myriad of minimally invasive techniques that are currently being utilized in addition to procedures performed by laparotomy.

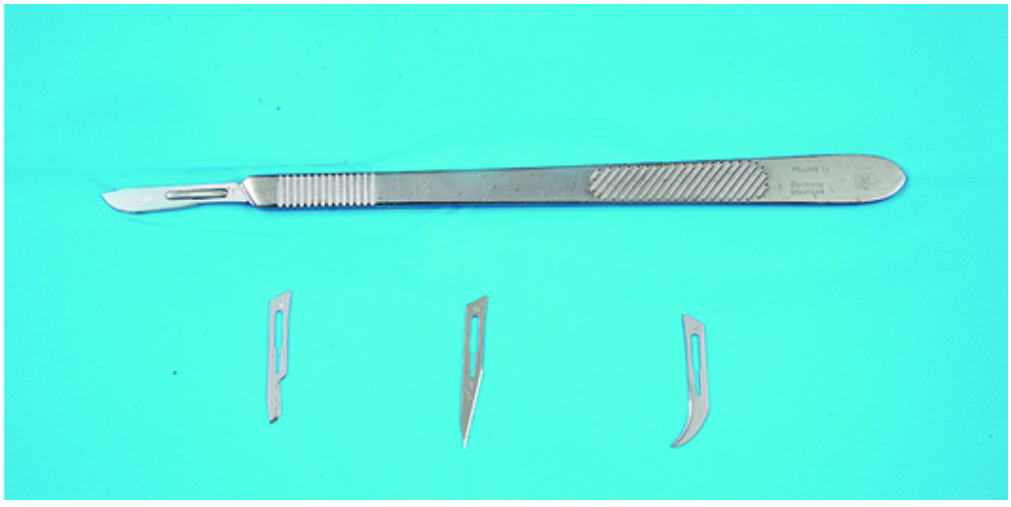
It is important that gynecologic surgeons learn by assisting primary surgeons in a variety of procedures, so that they can observe where the focus of an operation is located during crucial steps of the procedure. How does the primary surgeon expose vital

structures? How are tissues dissected and how do the tissues react during dissection? How does the surgeon minimize tissue crushing and trauma at the operative site? What instruments and techniques are used to provide visualization during key steps of the procedure? How does the assistant respond during the procedure to maximize efficiency and safety of the procedure? These are concerns that should be considered throughout the surgeon's career, especially as new approaches to old operations are developed and surgeons will need to adapt to changes in surgical platforms and techniques in the future.

# SURGICAL INSTRUMENTS

## Scalpels

The scalpel is the most basic surgical instrument. In essence, it is a sharp blade that is used to cut or divide tissue with minimal tissue crushing and trauma. Detachable disposable stainless steel blades are assembled on handles of various lengths. It is important to change blades during a procedure when they become dull so that they perform predictably (**FIG. 6.1A**).



A

B

**FIGURE 6.1** **A.** Assembled surgical scalpel with no. 10 blade. Left to right below: no. 15, no. 11, and no. 12 (hook) blades. (Courtesy of John T. Soper, MD.) **B.** Proper technique for grasping the scalpel during abdominal entry. (Courtesy of John T. Soper, MD.)

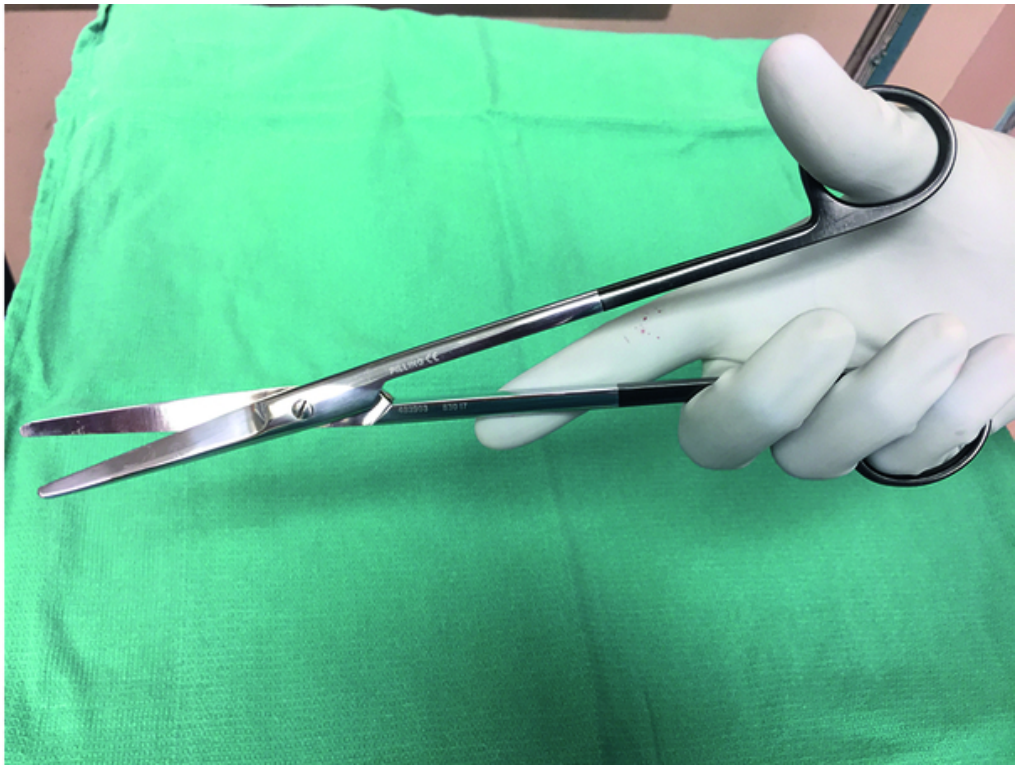
The classical scalpel blade has a straight ribbed back and oval cutting surface. The number 10 blade is most often used for incising the skin, subcutaneous tissues, and deeper fascial layers, while smaller blades (no. 15, 20, and 22) are used for more delicate dissection. When opening the abdomen, the scalpel handle should not be grasped in a “pencil grip”; rather, the handle should be grasped in an overhand grip with the index finger extended along the handle and proximal back of the blade. This promotes use of the long cutting surface rather than the point of the scalpel to incise tissues. The weight of the hand contributes to the force applied for

division of the tissue, and the surgeon can receive tactile information about division of the tissue as it occurs (**FIG. 6.1B**).

Other scalpel shapes include the triangular no. 11 blade, which unlike the other blades is pointed and is frequently used for “stab” incisions for drain placement or small deep incisions during the development of a cervical cone biopsy specimen. The no. 12 hook blade is infrequently used in gynecologic procedures.

## Scissors

A variety of scissors are used in gynecologic surgery. Surgical scissors not only divide tissues but can also be used to open surgical spaces by advancing the tips into a surgical plane and opening the blades so that the dull back portion of the blades dissects the tissue. Scissors should be held by placing the thumb and ring fingers in the opposing rings and extending the index and middle fingers along the shaft of the handles and proximal blades. This stabilizes the blades while dissecting or cutting tissue. Curved scissors should usually be held so that the curve of the scissors mirrors the curve of the fingers during dissection of tissue (**FIG. 6.2A**).



A

B

C

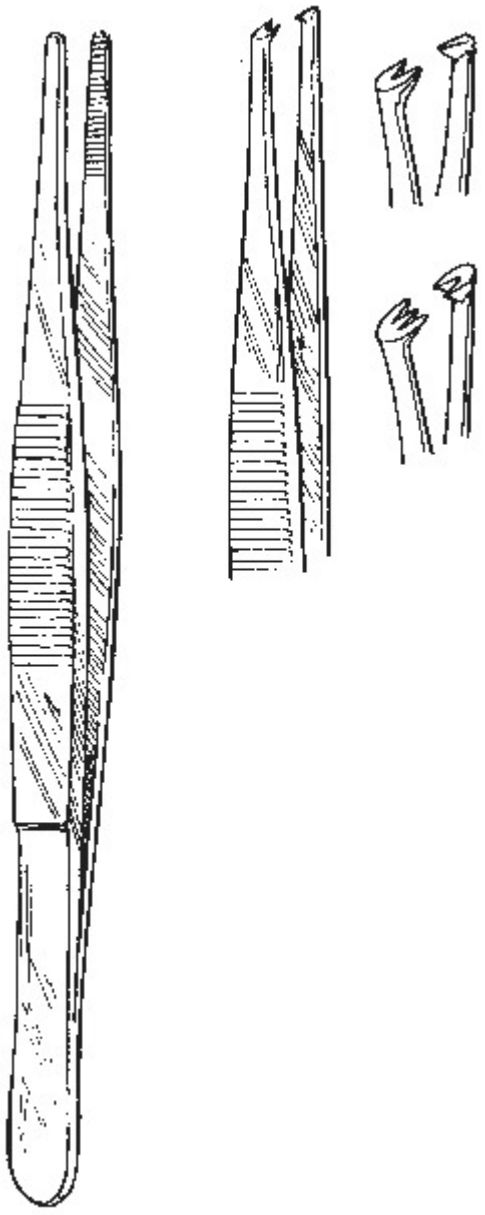
**FIGURE 6.2** **A.** Proper technique for manipulating surgical scissors. (Courtesy of John T. Soper, MD.) **B.** A variety of Mayo-type scissors. Note that the straight blade Mayo scissors at the far right are intended for cutting suture, not tissue. (Courtesy of John T. Soper, MD.) **C.** A variety of Metzenbaum-type scissors. (Courtesy of John T. Soper, MD.)

Mayo scissors have thick, slightly curved blades with blunt ends and are designed for cutting fascia or thick pedicles (**FIG. 6.2B**). There are several variations with several lengths of handles or blades. Jorgenson scissors are a variation of the Mayo scissor design with sharply curved blades. These are used to incise the vaginal cuff below the cervix during a hysterectomy. Suture scissors are similar in design to the Mayo scissors but have straight blades and blunt tips. Rotating the tips 45° facilitates cutting suture. The tips of the scissors should be kept in view when cutting suture to avoid accidental injury, and the suture should be cut using the scissor tips. Suture scissors tend to be dull and should not be used to cut tissue.

Metzenbaum scissors have longer handles and more delicate curved blades suitable for cutting delicate tissues, such as peritoneum or filmy adhesions (**FIG. 6.2C**). Potts scissors have straight blades with sharp tips that are angled in the plane of the handles. They are often used to divide and spatulate ureters.

# Tissue Forceps

The basic tissue forceps comprise two straps of metal joined at one end (**FIG. 6.3**). These are used to hold and manipulate tissue during dissection or suturing or for temporary hemostasis.



Smooth Toothed

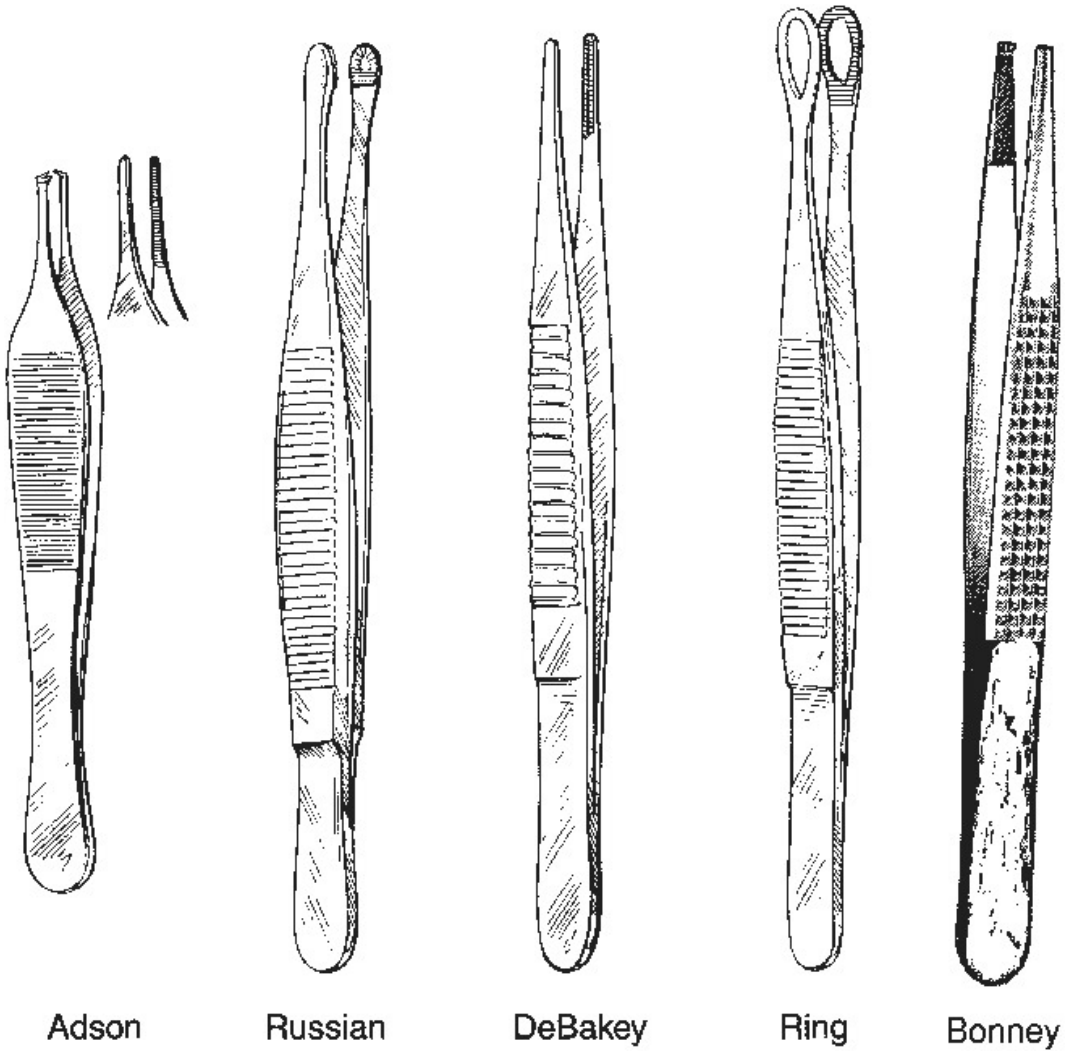



**FIGURE 6.3** Tissue (thumb) forceps. (Courtesy of Zinnanti Surgical, Santa Cruz, CA.)

Smooth forceps have fine serrations at the end to grasp vessels, or highly vascular, or delicate tissue. DeBakey forceps have delicate finer tips and are usually ineffective at grasping thick tissues or applying significant traction but can grasp delicate tissue in small areas. Blunt/smooth forceps have wider tips but no teeth and are suitable for grasping and manipulating denser tissues. Russian forceps have blunt indentations and splayed concave tips to increase the surface to atraumatically grasp tissue. Ring-tipped forceps

feature atraumatic ring tips to increase the surface area for secure grasping of tissue.

Toothed forceps have teeth at the end that "bite" into tissue, providing a firm grip of heavy tissues, such as fascia. Bonney forceps feature heavy toothed ends and a sturdy serrated shaft. They are mainly used to grasp fascia. Rat tooth forceps are more delicate than Bonney forceps. They feature opposing tips with double and single teeth. These are most useful to securely grasp and manipulate tough tissue such as the fascia or vagina. Adson forceps are lighter in weight with fine teeth and are most often used to manipulate skin during staple or suture closure (**TABLE 6.1**).

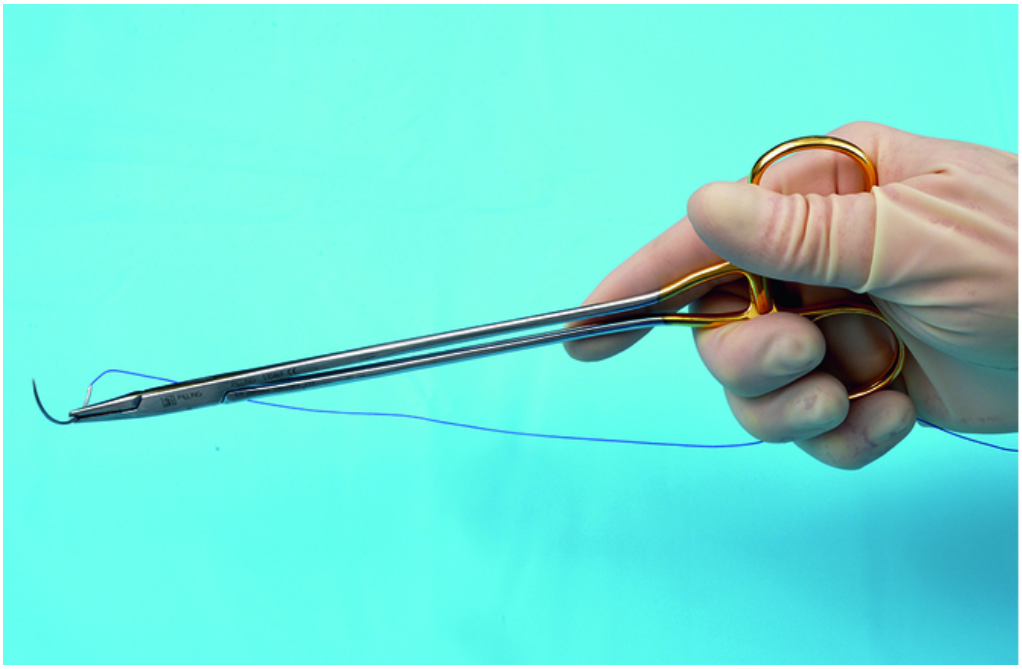
## TABLE 6.1
## Features of Frequently Used Surgical Forceps in Gynecologic Surgery

| TYPE OF FORCEPS | FEATURES | USES |
|---|---|---|
| Smooth | Medium weight straps, wide smooth tip with atraumatic serrations | Grasping and manipulating tissues |
| DeBakey | Light weight straps, narrow smooth tip with atraumatic serrations | Grasping delicate tissue or blood vessels |
| Russian | Heavy straps, splayed and concave tip with atraumatic serrations | Grasping dense tissue (eg, fascia) |
| Ring | Open ring at tip with atraumatic serrations | Grasping lymphatic or fatty tissue |
| Bonney | Heavy straps with toothed tips | Grasping dense tissue (eg, fascia) |
| Rat tooth | Medium weight straps with toothed tips | Grasping dense tissue (eg, fascia) |
| Adson | Light weight straps, either fine toothed or blunt tip | Grasping skin |

# Needle Drivers

The majority of needle drivers used in open gynecologic surgery are locking clamps that have handles of various lengths and short jaws (**FIG. 6.4A**). Cross-hatched ridges on the jaws allow secure grasping of the needle. Most needles should be grasped approximately one-third from the suture end. It is most efficient to drive the needle using pronation/internal rotation of the wrist, rather than driving the needle "backhanded" through tissue. Driving the needle is most flexible if the fingers are outside of the rings when passing the needle through tissue (**FIG. 6.4B**). Needle drivers have a variety of handle lengths to accommodate the depth of the surgical field.

A



B

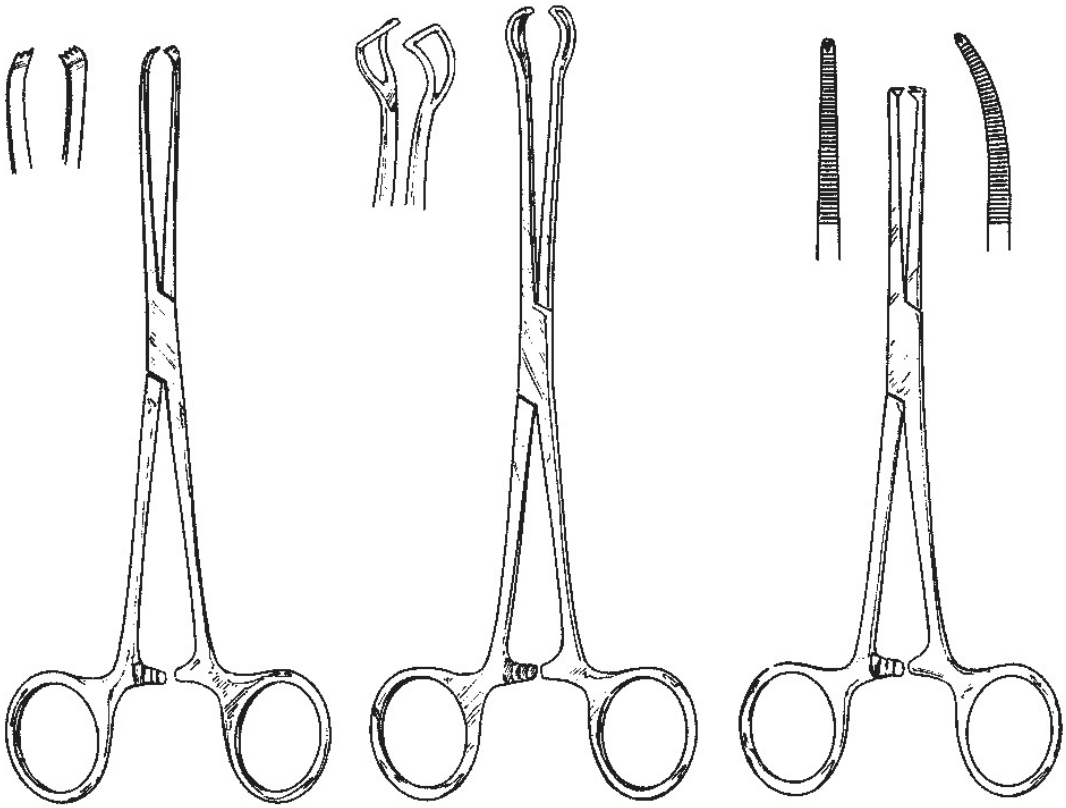
**FIGURE 6.4** **A.** Straight (*left*) and Heaney (*right*) needle drivers. (Courtesy of John T. Soper, MD.) **B.** Proper technique for manipulating the needle driver. (Courtesy of John T. Soper, MD.)

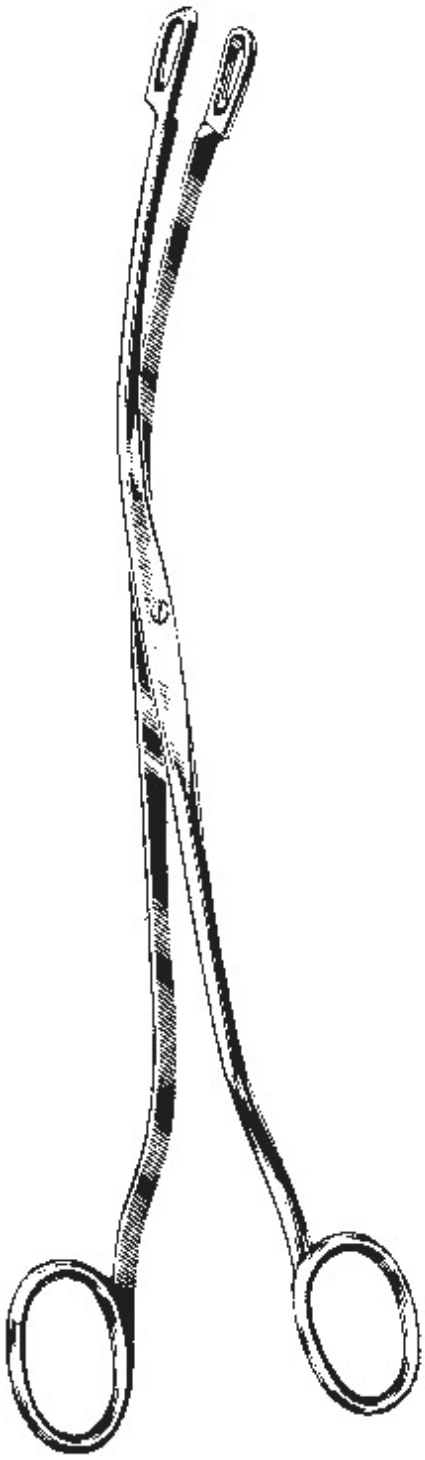
Straight needle drivers, as the name implies, have jaws that are not curved. The jaws range in size and bluntness of tips. Smaller needle drivers should not be used with large needles. The needle can be grasped at a >90° angle to accommodate driving the needle in a restricted field. Heaney needle drivers have curved tips and are designed to drive a needle in a restricted operative field. They are used most often for vaginal surgery. It is important to load the needle with tip oriented to the convex surface of the jaws to facilitate proper placement.

## Tissue Clamps

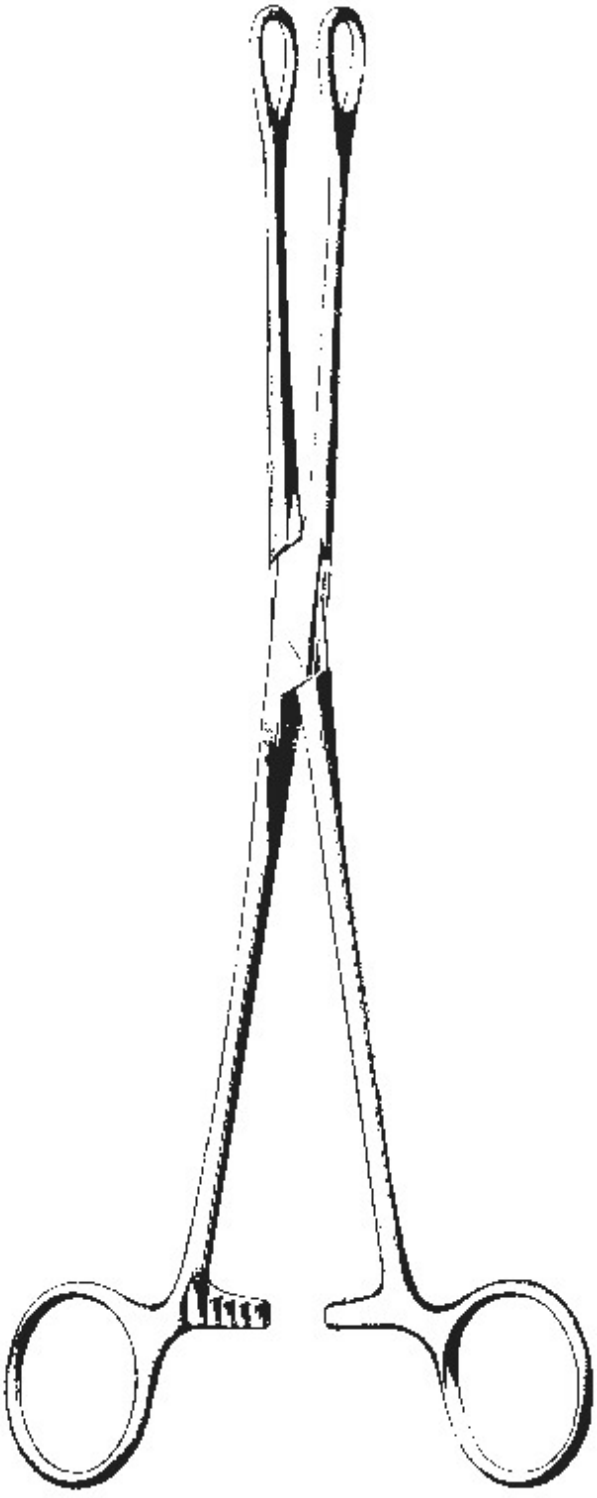
These clamps are designed to grasp tissue and apply pressure. A variety of clamps are available for many different applications (**FIG.**

**6.5**). Almost all tissue clamps feature finger rings with a locking device.





Stone or polyps



Sponge

**FIGURE 6.5** Tissue clamps. (Courtesy of Zinnanti Surgical, Santa Cruz, CA.)

Hemostatic clamps feature transverse ridges along the distal jaws of the clamps. They are designed to securely occlude blood vessels or vascular tissue and are available in a wide variety of sizes. Kelly clamps have blunt tips. They are used most often to occlude blood vessels but are generally not stout enough to clamp thick tissue. Tonsil clamps feature pointed tips that can be used for dissection in addition to grasping small vascular pedicles. Anderson clamps are similar to tonsil clamps, with pointed tips, but have longer handles and are usually used on delicate vascular pedicles such as the infundibulopelvic ligament.

The Babcock clamp features a smooth atraumatic tip, useful for grasping delicate tissue such as fallopian tube, bowel, or ureter. In contrast, the Allis clamp has flared serrated edges with short, fine teeth at the tip. These are often used for elevation of endopelvic fascia/vaginal flaps for anterior or posterior vaginal repairs or the cut edges of the vaginal tube at hysterectomy.

Kocher clamps have transverse ridges along the jaws and heavy toothed ends for gripping fascia or tough tissues such as the cut edges of the vagina. They are sometimes used as a hysterectomy clamp; the tissue within the clamp is unlikely to slip, but the teeth at the end of the clamp may produce trauma and bleeding when used for this purpose.

A variety of locking clamps are available for clamping the parametrial and paracervical tissues during hysterectomy (**FIG. 6.6A**). Heaney or Heaney-Ballentine clamps are relatively short, heavy crushing clamps with ridges and blunt teeth along the jaws. These can be found as curved or straight clamps. Masterson clamps are also heavy crushing clamps similar to Heaney clamps but with no teeth and usually have longer handles than Heaney clamps.

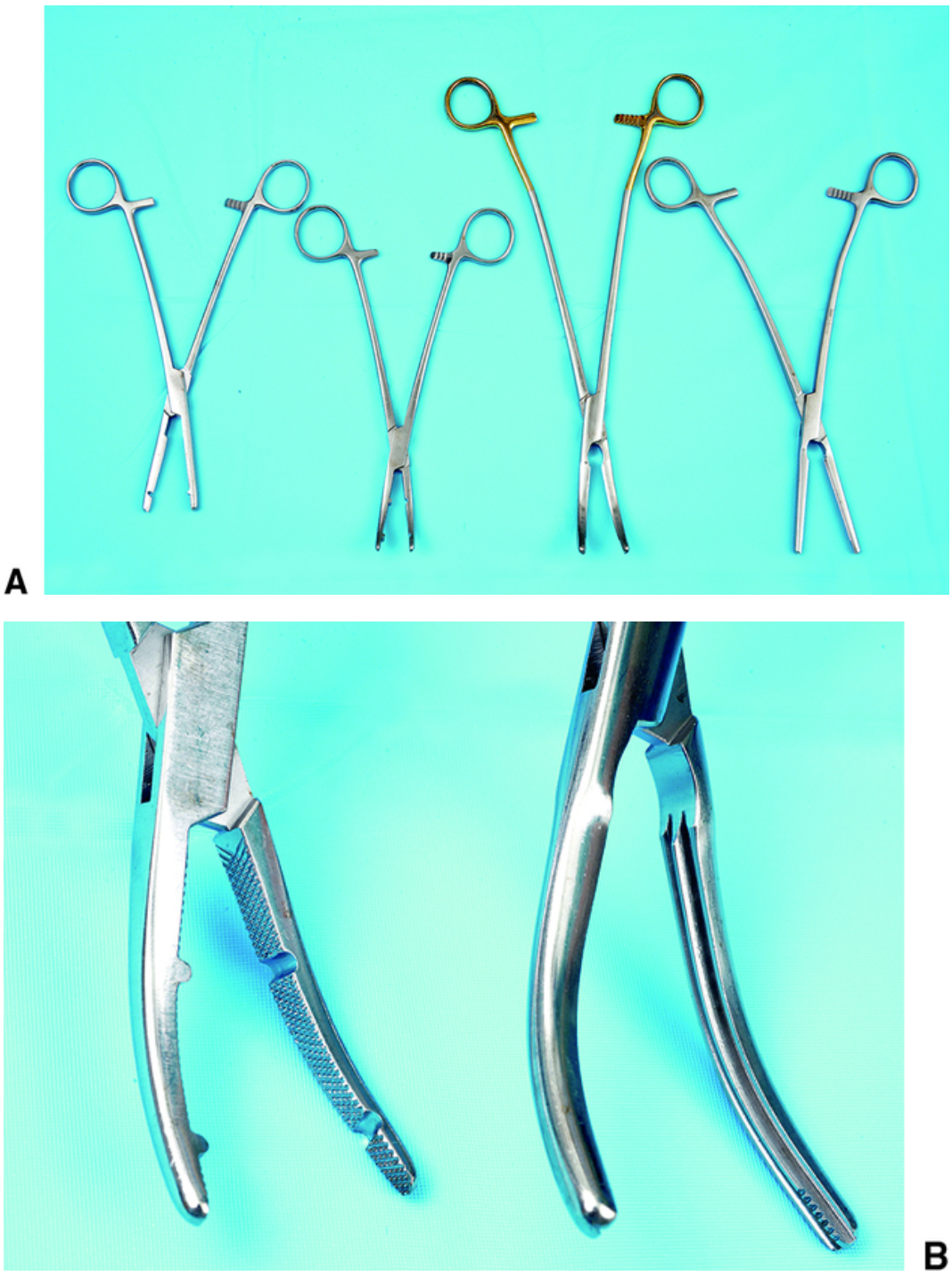



**FIGURE 6.6** **A.** Straight and curved Heaney (*left*) and Zeppelin (*right*) hysterectomy clamps. (Courtesy of John T. Soper, MD.) **B.** Comparison of Heaney (*left*) and Zeppelin

(*right*) clamp jaws. (Courtesy of John T. Soper, MD.)

Zeppelin ("Z") clamps or parametrial clamps feature longitudinal and cross-hatched ridges on jaws with a cutout on each shaft. They are designed to reduce the force of the closed jaws, so they are noncrushing and produce less tissue necrosis than do Heaney or Masterson clamps (**FIG. 6.6B**).

It should be noted that curved hysterectomy clamps should be applied with the concave curve of the clamp oriented toward the uterus. Application of the clamp with the concave curve facing away from the uterus could allow the tips of the clamp to migrate laterally as pressure is applied, placing the ureter in jeopardy.

Bowel clamps are atraumatic clamps used to occlude the bowel during intestinal surgery and reduce spillage of bowel contents. Vascular clamps are also atraumatic. They are available in a variety of configurations—straight, angled, and curved. They are designed to occlude large blood vessels such as the venae cava or major arteries with minimal tissue disruption or crush injury to the wall and intima of blood vessels (**TABLE 6.2**).

## TABLE 6.2
## Features of Surgical Clamps Frequently Used in Gynecologic Surgery

| TYPE OF CLAMP | FEATURES | USE |
|---|---|---|
| Hemostat | Short to medium handles, curved or straight jaws with transverse ridges and pointed tip | Clamping blood vessels or surgical sutures |
| Kelly | Short to medium handles, curved jaws with transverse ridges and blunt tip | Clamping vascular pedicles |
| Tonsil | Short to medium handles, curved jaws with transverse ridges and pointed fine tip | Clamping individual vessels, tissue dissection |
| Anderson | Long handles, curved jaws with transverse ridges, pointed tip | Clamping individual vessels or vascular pedicles (eg, infundibulopelvic ligament) |
| Babcock | Variable handle length, straight open tip with no ridges or teeth | Grasping delicate tissue (eg, fallopian tube, ureter, bowel) |
| Allis | Variable handle length, straight flared tip with serrated short teeth | Grasping fascia or tough tissue (eg, cut edges of vaginal tissue) |
| Kocher | Variable handle length, straight or curved jaws with transverse ridges and heavy interlocking teeth at tip | Grasping fascia or tough tissue (eg, cut edges of vaginal cuff) |
| Heaney, Heaney-Ballentine | Heavy medium length handles, straight or curved jaws with angled ridges and blunt teeth in the mid to distal jaws | Crushing clamp; clamps parametrial and paracervical tissues during hysterectomy |
| Masterson | Heavy long handles, straight or curved jaws with interlocking longitudinal ridges | Crushing clamp to clamp parametrial and paracervical tissues during hysterectomy |
| Zeppelin | Heavy long handles with a "cut out," straight or curved jaws with longitudinal and cross hatched ridges | Noncrushing clamp; clamps parametrial and paracervical tissues during hysterectomy |
| Mixter | Variable length handles; 90° angled jaws with transverse ridges and pointed tip | Clamping blood vessels, tissue dissection |
| Ring (sponge) | Variable handle length, straight or curved jaws with open ring with serrations at tip | Use with folded sponge to absorb fluids on the surgical field or apply pressure to bleeding tissues |
| Tenaculum | Variable handle length, curved or straight ending in single or multiple teeth | Piercing and grasping the cervix during D & C or vaginal hysterectomy |
| Stone (polyp) | Curved nonlocking handles, open elliptical tip with serrations | Removal of uterine polyps during D & C |

# Other Clamps and Instruments

The right-angle Mixter clamp is a locking hemostatic clamp with a relatively sharp tip angled at ~90°. These are excellent for controlling small bleeding vessels in a restricted space. They are also often used to spread and elevate tissue during dissection.

The Kitner "peanut" is a small cotton pledget grasped at the tip of a clamp, most often a Kelly or tonsil clamp. The Kitner is used to dissect areolar tissues by rubbing or pushing against a plane. It is often used to dissect the bladder away from the endopelvic fascia in the vesicovaginal space.

Ring or sponge forceps are long-handled locking clamps that have a ring at the tip with moderate grooves. They can be used to grasp tissue but are most often used to grasp a folded small sponge. They can provide pressure in areas of surgical bleeding to blot blood

or fluid when used with sponge, retract tissue, or apply prep solutions to the skin or vagina.

Tenaculums can be single toothed or have multiple teeth, such as the Lahey tenaculum. These toothed tissue clamps are designed to pierce and secure tissue. They are often used to grasp the cervix and apply traction during vaginal hysterectomy and to grasp and maneuver leiomyomas during abdominal hysterectomy or myomectomy.

Long and curved Stone forceps have an open elliptical ring at the end with grooves. They were originally designed for removal of kidney stones or gallstones but are often used for exploration of the uterine cavity during D & C. In this application, they are inserted through the dilated cervix, opened, rotated within the uterine cavity, and then closed to remove uterine polyps or detached uterine curettings.

Cervical and uterine curettes are designed to scrape tissue from the lining of the cervical canal or uterine cavity. The Kevorkian cervical curette is narrow enough to pass into an undilated cervix to obtain cervical curettings. Uterine curettes are looped at the end and available in a variety of sizes. Sharp uterine curettes are used for diagnostic dilation and curettage, employing the largest curette that can pass through the dilated cervix with gentle pressure. Suction curettes are used for pregnancy terminations, evacuation of miscarriages, and evacuation of hydatidiform moles.

## Cervical Dilators

Dilators are metal or plastic rod-shaped instruments used to dilate the cervical os with minimal trauma to allow passage of other surgical instruments, such as curettes or stone forceps. Pratt dilators have tapered ends, while Hegar dilators have rounded tips. The dilators with tapered ends require slightly less force to dilate the cervix and may dilate with less tissue trauma, but smaller diameter tapered dilators can produce false passages into cervical stroma or myometrium more easily than dilators with rounded tips. During cervical dilation, the cervix is stabilized with a tenaculum and dilated with dilators of serially increasing circumference. Dilator size is

specified in French units, which correspond roughly to the circumference measured in millimeters. See Chapter 14 for additional discussion of instruments for dilation and curettage.

## Suction Devices

The Yankauer suction device features a slightly curved metal or plastic tube with a large central opening and a few small apertures at the blunt tip. This is effective for suctioning fluid from an open space or directed local suction. It is often used as a dissecting tool. The pool suction device comprises a straight double-walled suction device with multiple side holes in the outer shell. This allows suctioning of pooling fluid between structures, such as large volume ascites or irrigation between loops of bowel.

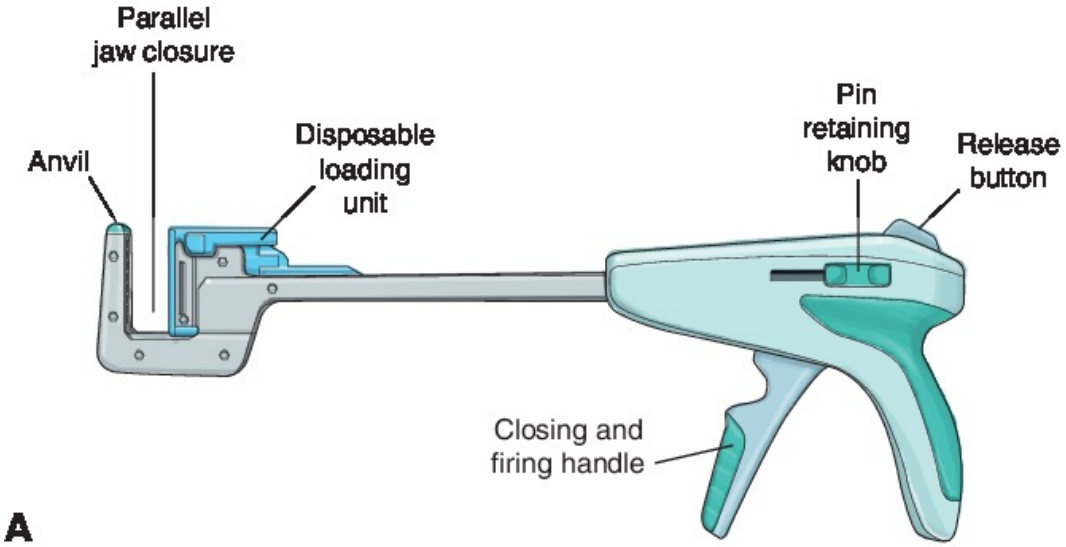
There are several reusable or disposable devices that allow simultaneous suction and irrigation of the operative field. These long instruments are designed to pass through laparoscopic ports for use during minimally invasive surgery. Instruments of 5 and 10 mm diameter are available.

The Cell Saver device is a suction system with a canister that uses centrifugal force to separate suctioned blood cells from irrigation fluid and serum. A small amount of heparin is added to prevent clotting. The salvaged blood cells can then be transfused. It is most often used when there is a possibility of significant blood loss, without contamination by infected tissues or bowel content, particularly in Jehovah's Witness patients who will not accept transfusions. See Chapter 39 for additional description of use of Cell Saver.

## Stapling Devices

Originally designed in the Soviet Union in the 1960s, stapling devices allow closure of bowel or blood vessels with a secure, nondevitalizing double row of staples. Each device has a preloaded cartridge with staples and can be reused several times with replacement of the cartridge only for thoracoabdominal (TA) and gastrointestinal anastomosis (GIA) staplers. End-to-end anastomosis

(EEA) staplers are not reusable. Staple lines are laid down with a consistent pressure and individual staples secured in a “B” configuration that allows blood flow to the edges of the divided tissue. Staples are available in a variety of sizes also. The 2.5-mm staples that close to 1.0 mm are used for vascular structures. Staples of 3.5 mm that close to 1.5 mm or staples of 4.8 mm that close to 2.0 mm allow perfusion along the staple line and are used for dividing the bowel. These are efficient and rapid compared to hand-sewn bowel closures. Modifications of the original devices have been developed so that they can be used in open or laparoscopic surgery. There are slightly different specifications for models from different manufacturers (eg, Ethicon, Covidien). The TA stapler (**FIG. 6.7A**) produces a double row of staples across tissue but does not divide the tissue. It is available in a variety of lengths (30, 60, 90 mm). A cartridge with absorbable staples has been developed for vaginal closure.



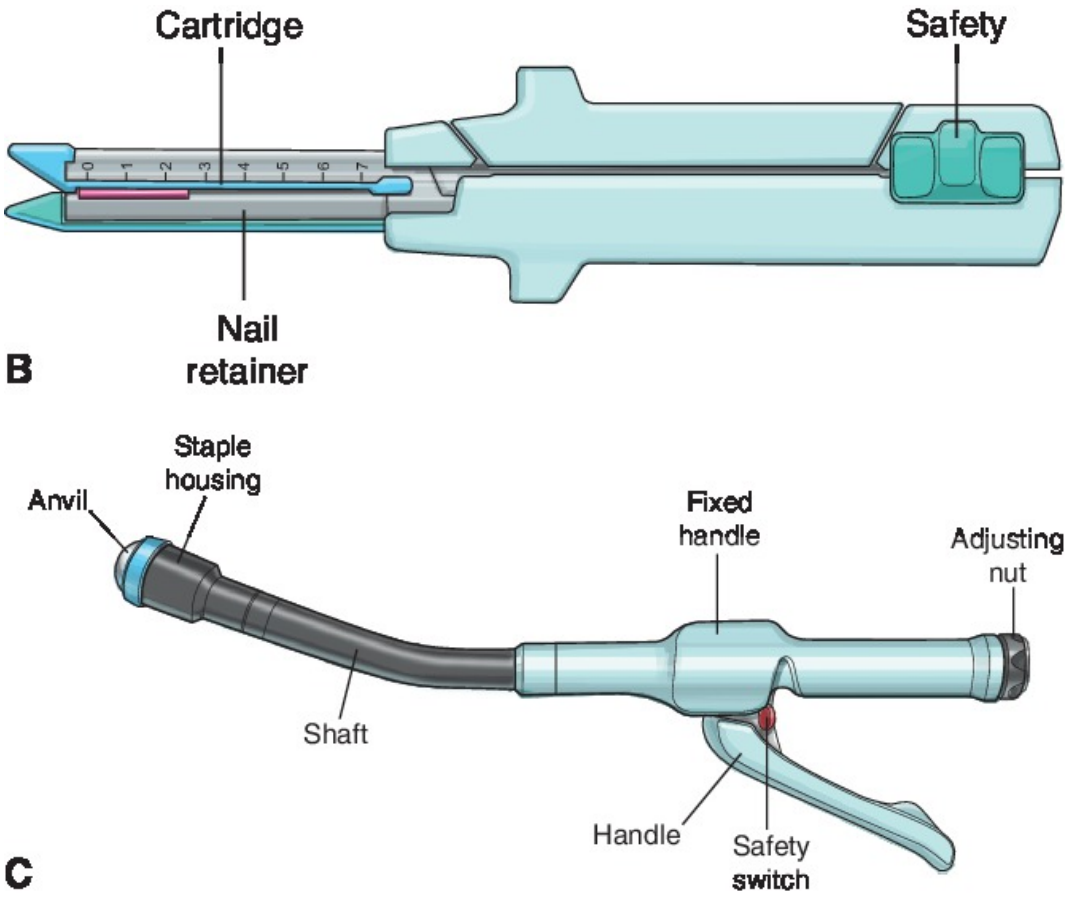



**FIGURE 6.7** Surgical staplers most often used in gynecologic surgery include **(A)** thoracoabdominal (TA), **(B)** gastrointestinal (GIA), and **(C)** end-to-end anastomosis (EEA).

The GIA or linear stapler staples and divides simultaneously (**FIG. 6.7B**). This stapler is available in a variety of lengths also (60, 80, 100 mm) and is most used for bowel surgery.

Two double rows of staples are produced as the stapler is deployed, simultaneously advancing a blade between the staple lines to divide the tissue. This is used to divide bowel and in combination with the TA stapler and can produce a side-to-side (functional end-to-end) bowel anastomosis. It can also be used to divide the infundibulopelvic ligament or lateral cardinal ligaments

during radical hysterectomy using vascular staples. A cartridge with absorbable staples has been developed for vaginal closure.

The EEA device (**FIG. 6.7C**) has an anvil with a “male” center post that is inserted into the lumen of the bowel, and the edges of the bowel are secured to the center post with a purse-string suture. The handle of the device is inserted into the other segment of the bowel, either through an enterotomy or via the anus. This contains a “female” center post that is extended either through a staple line or the wall of the other segment of the bowel. The male and female ends of the center post are joined. The anvil is retracted, and when in sufficient contact, the device is fired, simultaneously deploying a circular double staple line and cutting both segments of bowel inside the staple line. This produces an end-to-end anastomosis. It is most frequently used to anastomose the large intestine when resection of the distal sigmoid colon has been performed for debulking gynecologic malignancies.

# Mechanical Hemostatic Devices

Hemoclips are applied to blood vessels to mechanically occlude the lumen and are available in a variety of sizes. Titanium clips are permanent, are nonreactive, and are nonmagnetic so that magnetic resonance imaging scans can be performed without displacing clips that have been applied to vascular structures. Absorbable clips are constructed from polymers similar to absorbable suture material, with locking tips. Similar clips have been developed for tubal occlusion procedures. Clips can be applied manually or with an autoclip applier.

# Harmonic Scalpel

The Harmonic scalpel provides rapid mechanical oscillation of a metal blade against a ceramic blade. This produces friction and ultimately heat to denature proteins and seal vessels up to 5 mm in diameter. With appropriate tension on tissues, it can divide tissues, such as the peritoneum. The cavitron ultrasonic surgical aspirator (CUSA), or ultrasonic rapid oscillation device, is combined with

suction to fragment the tissue and suction up the fragmented remains of the tissue. The heat produced by the rapid oscillation denatures proteins and seals small vessels. These are used in gynecologic oncology procedures by some surgeons to resect peritoneal tumors.

## Handheld Retractors

Handheld retractors (**FIG. 6.8**) are the most versatile retractors and can accommodate most retraction needs. However, these require a second surgical assistant, who is not actively involved in the surgical procedure and whose only function is to provide exposure of the surgical field.

**FIGURE 6.8** Handheld retractors: wide malleable (*top*). *Left to right*: Two Richardson, one Acey-Decy, one Army-Navy, one vein

retractor, and two Deaver retractors. (Courtesy of John T. Soper, MD.)

The Army-Navy retractor is usually a thin shallow right-angle retractor with blades at both ends to provide retraction of the skin and subcutaneous tissues. The appendiceal retractor has a concave wide and shallow blade for skin and subcutaneous retraction with a wider exposure.

The Deaver retractors are curved retractors available in a variety of widths and lengths. The request to “toe up” or “toe down” a retractor refers to the surgeon’s request to increase pressure to the tip of the retractor to expose deeper tissues or to lay back into the retractor and increase the angle of retraction to expose a wider, more superficial field of exposure. The Richardson retractor is a right-angle retractor. This is available in a wide variety of widths and lengths. This retractor is invaluable for retracting and lifting the abdominal wall. The malleable retractor is a retractor with “ribbon” or straplike properties available in a variety of widths. These malleable retractors can be customized to fit specific retraction needs.

The Bayonet retractor provides a straight deep blade for vaginal surgery. This vaginal right-angle retractor provides a thin right-angle blade with long handles for vaginal retraction. A weighted speculum is often used to passively retract the posterior vaginal wall during vaginal surgery.

Vein retractors have smooth edges and an acutely curved tip. These are most often used for retraction of large blood vessels, such as the external iliac vessels during pelvic lymph node dissection or resection of a pelvic tumor that is adherent to the sidewall vessels.

# Fixed Retractors

These valuable surgical tools are held in position by opposing tissue traction created by the retractor blades (**FIG. 6.9**). The surgeon must take care when using fixed retractors in the abdomen to avoid pressure on the psoas muscles by lateral retractors. Pressure on the

femoral nerve roots underlying the psoas can cause injury, resulting in thigh flexion weakness.

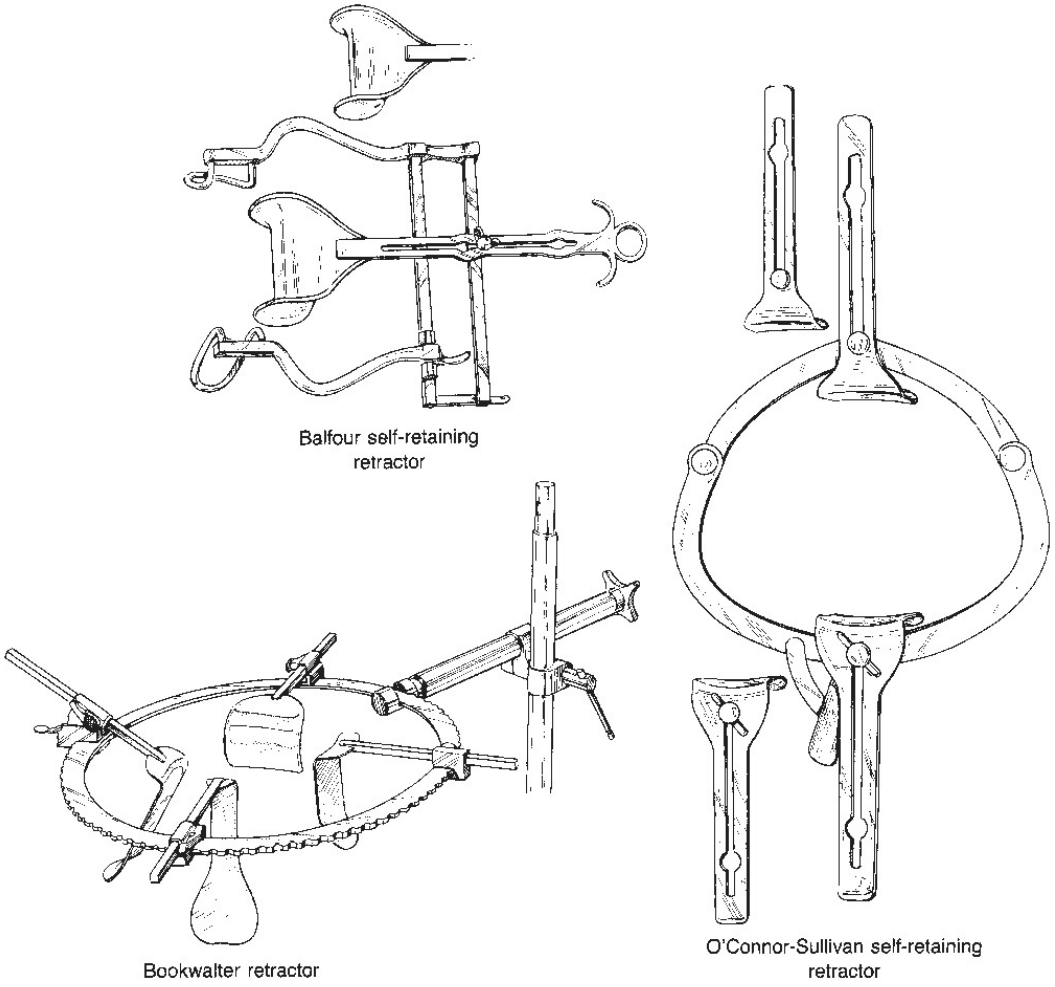



**FIGURE 6.9** Abdominal wall retractors. (Courtesy of Zinnanti Surgical, Santa Cruz, CA.)

Thyroid retractors have multipronged skin hooks at the ends of a locking clam. Bringing the finger rings together spreads the ends and exposes tissue. These retractors provide superficial exposure for dissections and in gynecologic surgery are often used for groin node dissections.

The O'Connor-O'Sullivan retractor has four blades, and the Balfour retractor has three blades; these retractors are more often used for uncomplicated gynecologic pelvic procedures. The O'Connor-O'Sullivan retractor has a fixed circumference when deployed, which limits the amount of exposure and is suitable for limited subumbilical incision exposure. The Balfour retractor has two sidewall retractors and a bladder retractor; this configuration allows excellent pelvic exposure but is limited in the ability to pack the intestines out of the operative field.

The Bookwalter retractor and its modifications are the most versatile types of retractors for major abdominal and pelvic procedures. The retractor is fixed to the operating table with a post for stability. A serrated ring allows attachment of multiple right-angle, curved, or malleable retractors. The ring is available in a variety of sizes and can be angled so that it can be adapted to almost any abdominal incision or for use in complicated vaginal surgeries (**VIDEO 6.1**).

# SUTURE

A large variety of natural and synthetic materials are available for use in surgery. The gynecologic surgeon should have a functional understanding of the properties of different suture materials and their applications. Absorbable sutures are used when tissues that do not require long-term stability are sutured. Examples where absorbable sutures are suitable include suturing ureter, bladder, or urethra; use of a permanent suture in the urinary system can serve as a nidus for stone formation. Absorbable sutures are used to control pedicles in hysterectomy so that there is no long-term bunching of tissues around the distal ureters. Permanent sutures penetrating the vaginal mucosa result in chronic inflammation and are generally not used for closure of vaginal incisions. Permanent suture material is often used for closure of fascia or where long-term structural integrity is needed, for example, in sacrospinous ligament vaginal suspensions. Additional discussion of suture and their use is discussed in Chapter 8.

The U.S. Pharmacopeia (USP) defines various classes and standards for suture tensile strength and diameter. Size categories of sutures are based on diameter. Sutures larger than 0 are numbered by increasing numerical order, while sutures smaller than 0 are defined by increasing number of zeros (00, 000, etc.). The smaller sutures are referred to numerically as 2-0, 3-0, etc. where the first number designates the number of zeros.

The USP classifies suture material based on rate of absorption in the body and whether composition is natural or synthetic materials. Absorbable sutures lose most of their tensile strength in body tissues within 60 days as illustrated in **FIGURE 6.10**. Nonabsorbable sutures retain tensile strength >60 days and are further divided into three classes. Class I comprises silk or synthetic fibers, class II includes suture made of cotton or linen fibers or coated fibers (coating is added to improve handling or resist degradation, but not to increase tensile strength), and class III includes suture made of metal wire.

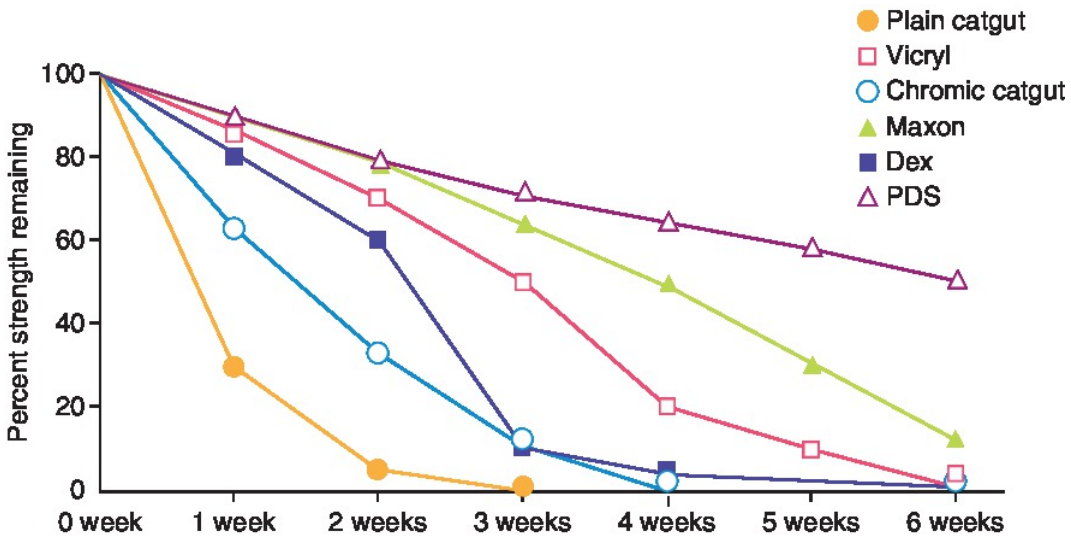



**FIGURE 6.10** Percentage of *in vivo* tensile strength of absorbable sutures remaining at various postoperative times.

## Natural Absorbable Sutures

Although these sutures are usually referred to as “catgut” sutures, they are manufactured using purified strands of collagen from the submucosa of sheep or cattle intestines. They are derived from foreign protein and are degraded by an inflammatory response resulting from enzymatic digestion from white blood cells. They are more rapidly degraded in infected tissues. These sutures should not be used on skin because the inflammatory response can cause scarring and serve as a nidus for infection. There is a theoretical concern for transmission of prions (“mad cow” disease) that has increased the cost of production. Because of these concerns, these materials have been taken off the market in Europe and Japan.

“Plain catgut” is rapidly degraded and loses >70% tensile strength at 7 days, eventually being totally degraded in about 70 days. This suture material is still used in Pomeroy tubal ligations because the suture degrades rapidly allowing the severed ends of the fallopian tubes to fall apart. This results in fewer fistulas than when using delayed absorbable or permanent sutures.

“Chromic catgut” sutures are treated with chromic acid salts that bind to the antigen sites on the suture material. This results in less inflammatory response and delayed absorption when compared to plain catgut. Chromic sutures retain >50% tensile strength at 7 days and continue to have a measurable effect at 21 days.

## Natural Permanent Sutures

In the past, many braided fibers (silk, cotton, linen) were used for closure of the fascia or other applications where a more permanent closure was desired. This suture material has good handling and knot tying characteristics, including security of knots. Braided silk is a foreign protein that elicits an inflammatory response and slowly degrades. It loses >50% tensile strength at about 1 year and is frequently absorbed or loses all tensile strength within 2-3 years. Because it is a multifilament braided suture, adjacent tissue fluid is absorbed into silk suture by capillary action, and it is not suitable for use in grossly contaminated or infected tissues.

## Synthetic Sutures

Advances in polymer chemistry since the 1970s have resulted in a variety of absorbable and permanent suture materials that have been engineered to mimic and improve upon the performance of natural suture materials. Unlike natural absorbable sutures, synthetic absorbable sutures are degraded by hydrolysis rather than an inflammatory response and elicit much less tissue reaction.

## *Synthetic Absorbable Braided Sutures*

Most frequently used in gynecologic procedures are polyglycolic acid (Dexon, Sherwood/Davis & Geck, St. Louis, MO), a polymer of glycolic acid, and polyglactin 910 (Vicryl, Ethicon, Somerville, NJ), a copolymer of lactic and glycolic acid. These have very similar biologic properties, and breakdown occurs by hydrolysis at a fairly constant absorption rate with limited inflammation. These retain 100% tensile strength at 7-10 days, 50%-60% at 14 days, 20%-30% at 21 days, and essentially complete absorption at 28 days. The initial tensile strength for these sutures is superior to chromic catgut of equal size.

Lactomer 9-1 (Polysorb: Covidien, Mansfield, MA) is composed of glycolide and lactide. To decrease the coefficient of friction, this suture material is coated with caprolactone/glycolide copolymer and calcium stearoyl lactylate. Tensile strength at 2 weeks is ~80% and at 3 weeks 30%, and total absorption occurs at 56-70 days.

Polyglactin 910 (Vicryl Rapide) suture is composed of low molecular weight polyglactin, treated with gamma rays to speed absorption. Similar to plain catgut, it loses 70% tensile strength in 7 days and all tensile strength lost by 10-14 days. It can be substituted for plain catgut and is absorbed without inflammation, so it can be used for skin closure.

## *Synthetic Absorbable Monofilament Sutures*

This type of suture is most often used in potentially contaminated fields and for closure of the fascia. In comparison with permanent suture material, delayed absorbable sutures produce fewer chronic

suture abscesses and sinuses while providing equivalent strength of the fascial closure.

Polyglytone 6211 (Caprosyn, Covidien) is a complex polymer with glycolide, caprolactone, trimethyl carbonate, and lactide. The absorption profile is similar to polyglactin 910. Poliglecaprone 25 (Monocryl) has an absorption profile similar to catgut. This suture maintains 50%-60% tensile strength at 7 days, 20%-30% at 14 days, and almost all tensile strength is lost by 21 days. Glycomer 631 (Biosyn: Covidien, Mansfield, MA) is a triblock polymer of glycolide, dioxanone, and trimethylene carbonate. It is a monofilament of equivalent strength as braided glycolic acid copolymers. The tensile strength is about 75% at 2 weeks, decreasing to 40% at 3 weeks.

Polyglyconate (Maxon) and polydioxanone (PDS) have very little reactivity and slow absorption with tensile strength >90% at 1 week, 80% at 2 weeks, 50% at 4 weeks, and 25% at 6 weeks. These sutures are most often used for closure of the fascia.

## Synthetic Permanent Sutures

Nylon is available as either braided (Nurolon, Surgilon) or monofilament (Dermalon, Ethilon) sutures. In general, there is better knot security with braided nylon. These are relatively inert and provoke minimal tissue reaction. It is degraded by slow hydrolysis in tissue, losing 15%-20% tensile strength/year.

Polyester suture is available in braided form only. Uncoated sutures (Mersilene, Dacron) have better knot security than coated sutures; however, coated sutures handle better. Polytetrafluorethylene or Teflon (Polydek, Ethiflex, Tevdek), polybutilate (Ethibond), and silicone (Tri-Cron) are similar sutures. Polypropylene (Prolene, Surgilon) is available as a monofilament suture, composed of a linear hydrocarbon polymer. These sutures have high memory but some plasticity; therefore, flattening knots when tying helps lock knots in place for greater knot security than nylon.

### *Synthetic Barbed Sutures*

Barbed sutures are used to provide a secure bite into tissue and distribute tension evenly along the suture line without needing to tie a knot. They are frequently used for laparoscopic vaginal cuff closure, for laparoscopic hernia repairs, and for some plastic surgery procedures. It should be noted that sizes for barbed sutures are the diameter measured from the tips of the barbs; therefore, a 0 barbed suture has a core that is equivalent to a 2-0 nonbarbed suture.

Quill sutures (Angiotech, Vancouver, BC, Canada) have bidirectional barbs with needles swagged to each end. Absorbable barbed suture (poliglecaprone 25, and polydioxanone) and permanent barbed suture (nylon, and polypropylene) are available. The V-Loc sutures (Covidien, Mansfield, MA) have unidirectional barbs with a single needle and looped end. Absorbable V-Loc sutures have a numerical designation to indicate the time in days to complete suture absorption: V-Loc 90 (glycomer 631) and V-Loc 180 (polyglyconate). V-Loc PBT is a polybutester, providing a permanent closure.

# Metal Sutures

Metal sutures can be monofilament or single stranded. They are nonreactive and have the greatest tensile strength compared to other suture materials but are used infrequently in abdominal surgery because of the availability of permanent suture materials that are easier to use and have adequate tensile strength and low reactivity.

# Surgical Needles

Surgical needles can be swedged (permanently attached to the suture end) or designed to pop off with minimal traction. Swedged needles are usually used when more than one pass-through tissue is required, such as a running suture line. Care should be taken to protect the end of the needle when tying one-handed knots with a swedged needle. “Pop-off” needles are generally employed for simple or figure-of-8 sutures and should be used with caution in suturing deep pedicles, because inadvertent release of an unguarded needle can cause a risk for needlestick injury. A variety of

needle shapes and profiles are used in surgical procedures (**FIG. 6.11**).

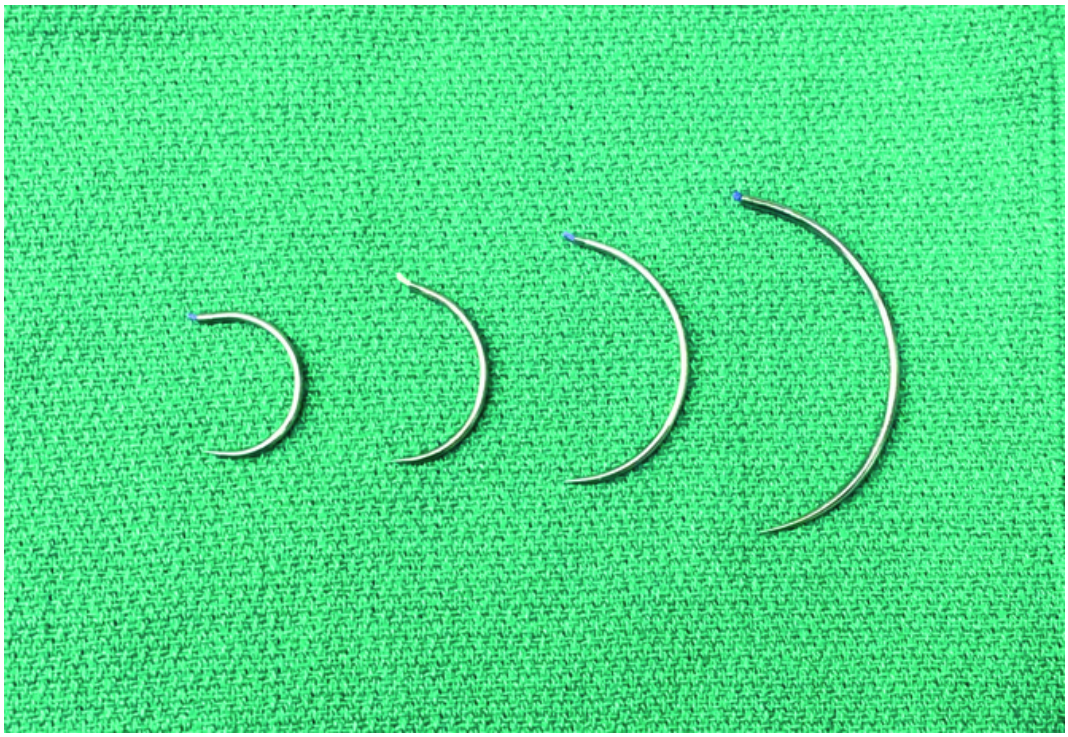


**FIGURE 6.11** Common body shapes for curved needles. *Left to Right*: UR-6 needle, CT-2 needle, CT-1 needle, and CTX needle.

Smooth needles have a round cross section and are designed to pass through vascular tissue or fascia with the least amount of trauma. Theoretically, the round profile pushes small vessels and tissue fibers to the side. A variety of sizes and profiles are available: CTX needles are very large, are stout, and are often used for closure of fascia. CT 1 and CT 2 needles are half-round and stout, frequently used for suturing parametrial and paracervical tissues during hysterectomy, and are often used for vaginal and fascial closure. SH needles have smaller cross section and shallower curve. Most often, these are used for GI or urological surgery. UR needles are fairly stout and tightly arced for driving a needle in an area with restricted

access. They are used for paravaginal and bladder suspension surgeries or closure of fascia for large abdominal port sites after laparoscopic surgery. RB needles have a very shallow curve and small cross section, useful for closing vascular lacerations.

Cutting needles have a triangular cross section that tends to lacerate vessels rather than push them to the side. A variety of curved profiles are available; these are used mainly for suturing skin. Straight needles (such as a Keith needle) with a cutting profile can be used for skin closure. Because straight needles are usually maneuvered without a needle driver, they should be handled with care to avoid needlestick injuries. When using these needles, suture away from or at 90° to the operator.

# Surgical Knots

Surgical knots are an important component of the surgeon's skill set. Although a seemingly mundane skill, it is important to practice knot tying with a variety of suture materials. Two-handed and one-handed knot techniques should be mastered, using both the dominant and nondominant hand so that a secure knot can be laid down during surgery under any situation, even when there is limited exposure.

Flat knots have more tensile strength over the first 2-3 throws than do sliding knots and are recommended for closure of the fascia. As an advantage, these knots are less likely to fail when using monofilament suture. A singular disadvantage to flat knots is that they are difficult to place deep in the pelvis or in scenarios with restricted lateral access. Square knots alternate the direction of overhand and underhand throws. They are not prone to failure because lateral tension increases security of the knot. In a surgeon's knot, two wraps comprise the first throw followed by square knot throws. The extra wrap on the first throw provides security with less slippage. A granny knot is developed with two identical throws—either overhand or underhand. An advantage is the ability to tighten the knot with the second throw. Although not quite as secure as square knot or surgeon's knot after the first 2-3 throws, optimal strength is reached after 4-5 throws and is roughly equivalent to a square knot.

Sliding knots are formed with alternating half-hitch throws around a taught suture. Alternating throws are more secure than identical throws. The advantages of a sliding knot over a flat knot include the ability to maintain tension on pedicle after the first throw. Also, they can be tied deep into narrow operating spaces. The main disadvantage with sliding knots is that they have less tensile strength than flat knot unless >3 throws are used. Most often, these are used for vascular pedicles deep in the pelvis.

It should be noted that using any of these techniques to join two sutures of unequal diameter or tying a single suture to a doubled loop of the same suture results in a knot with poor tensile strength. This is especially important when closing fascia with a running suture (**FIG. 6.12**).

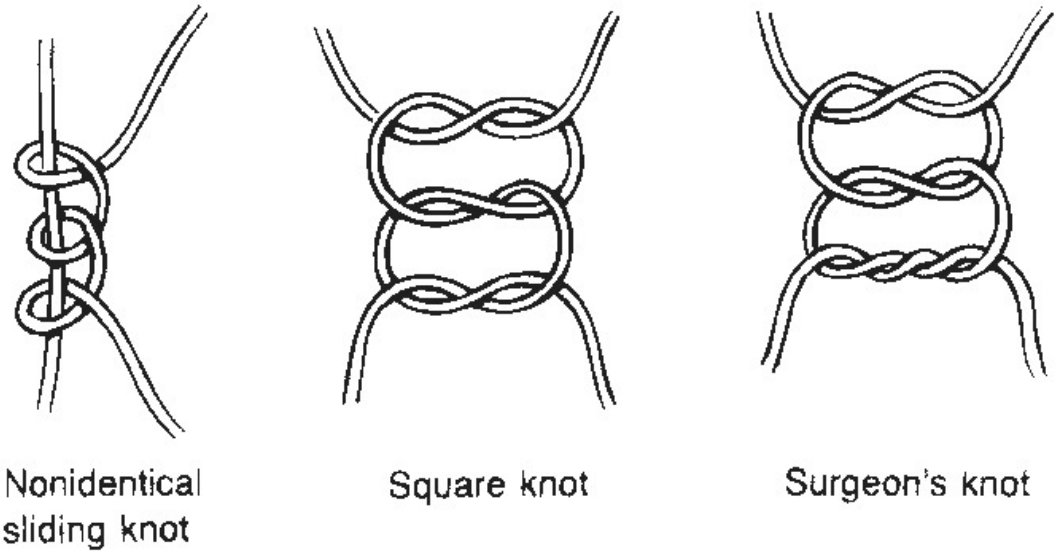



**FIGURE 6.12** Flat and sliding knots.

# SURGICAL TECHNIQUES

# Dissection Techniques

The student of surgery has to have a core of knowledge of the surgical anatomy before performing a surgical procedure. Many surgical procedures require repetitive mechanical tasks, such as dividing various tissues, tying knots, or driving needles through tissue. The muscle memory to perform mechanics of these repetitive tasks is internalized by repetition.

Each procedure can be broken down into discrete steps or objectives. During the learning years, the surgeon observes surgical procedures to internalize the steps needed to perform specific procedures and observes the maneuvers performed by experienced surgeons, most often while assisting the primary surgeon. Currently, there are many more learning videos, and for some platforms, simulations of surgical skills that can be reviewed before the learner performs surgery on a patient.

Surgical dissection is the mechanical process of exposing the pertinent surgical anatomy so that a given procedure can be performed without causing unnecessary risk of bleeding and damage to vital structures while causing minimal tissue trauma or devitalization. It is important to remember that most abdominal and pelvic structures are invested in a thin layer of visceral fascia. In the retroperitoneal regions, there is loose areolar tissue between these sheathes of visceral fascia that define potential spaces. Knowledge of the potential retroperitoneal spaces and their boundaries is vital to pelvic surgery.

In some procedures, the surgical anatomy is straightforward, while in other cases, there is distortion caused by inflammation, previous surgery, radiation, or malignancy. Especially in difficult procedures, surgical dissection must proceed millimeter by millimeter to restore relatively normal anatomical relationships. It is important to avoid blindly dissecting or cutting dense opaque tissue without assuring that vital structures are protected. Experienced surgeons combine a knowledge of the anatomy and surgical objectives of each procedure to operate efficiently and safely. Furthermore, they have learned how to make sense out of a visual field that is often

confusing, with key structures only partially visualized or obscured by blood or scarring.

## Elevate and Incise

This technique involves elevating a portion of a flat plane of tissue—usually fascia or peritoneum—between two grasping instruments to tent the structure. The tissue is incised with a scalpel or snipped with scissors to allow entry into the space below the tissue plane (**FIG. 6.13**).

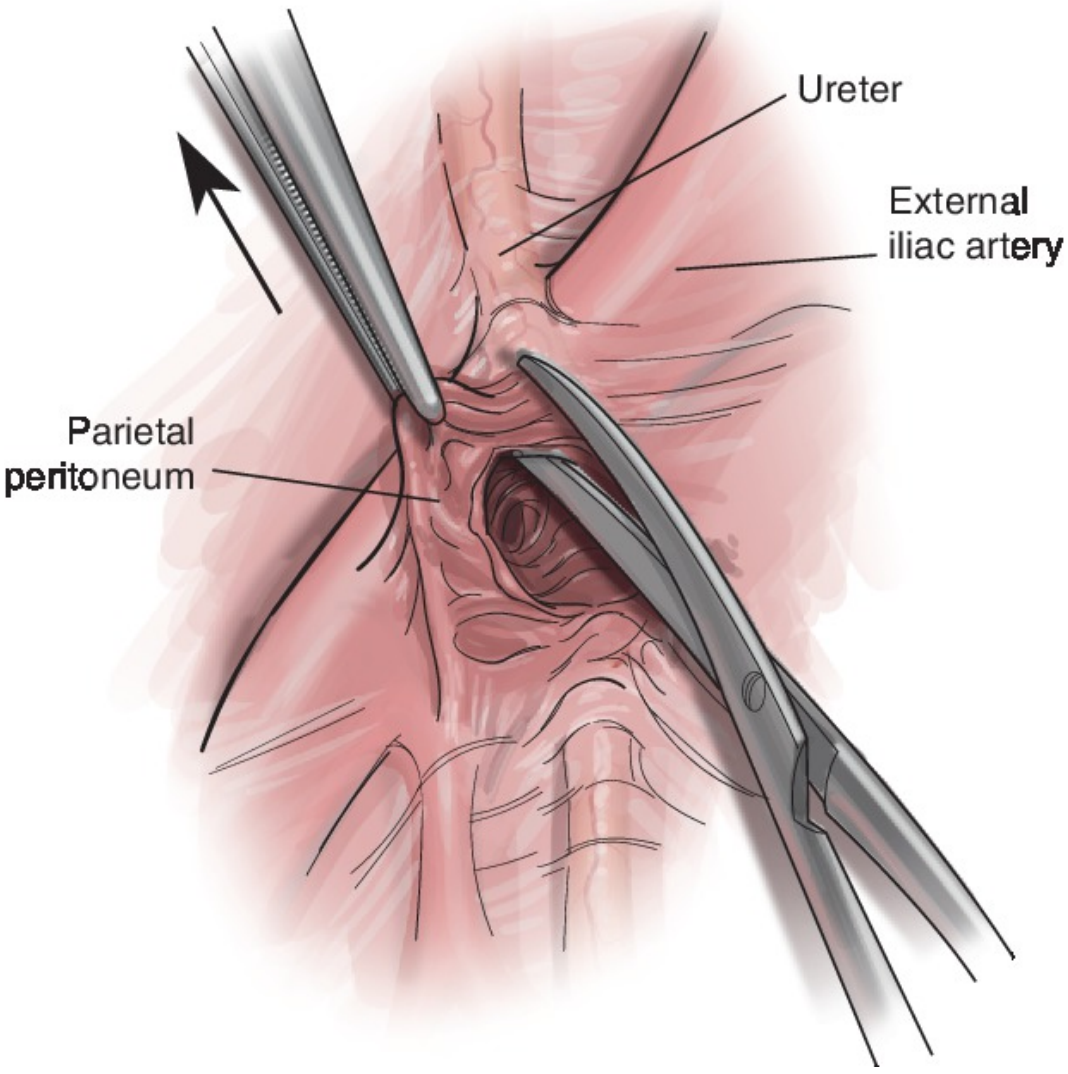


**FIGURE 6.13** Elevate and incise technique to enter peritoneum. (Redrawn from Rogers RM, Taylor RH. The core of a competent surgeon: a working knowledge of surgical anatomy and safe dissection techniques. *Obstet Gynecol Clin North Am*. 2011;38(4):777-788.)

This technique is used when entering the peritoneum during an abdominal incision after opening the skin, subcutaneous tissues, and fascia. The operator grasps and lifts the peritoneum with an atraumatic forceps or clamp. The other operator then grasps and lifts the peritoneum. The first operator releases the peritoneum, regrasps, and lifts before the peritoneum is incised between the forceps. This allows any bowel grasped with the initial elevation to fall away. The remainder of the peritoneum can then be incised after lifting the opposite edges to allow direct visualization.

When entering the retroperitoneal spaces, a peritoneal incision is initially made in a similar fashion. It is important to remember that a thin plane of visceral fascia underlies the peritoneum and must be divided before the retroperitoneal spaces can be easily developed.

## Push and Spread

In this maneuver, the tips of an instrument such as scissors or a right-angle dissecting clamp are introduced into a potential space and opened (**FIG. 6.14**). This opens the space partially, allowing repetitive spreading to gradually enlarge the space. Often, novice surgeons tend to back up with the dissecting instrument while opening the instrument for fear of damaging underlying structures. Two instruments (eg, forceps and scissors) can also be used to gently spread the tissue when a space is partially opened.

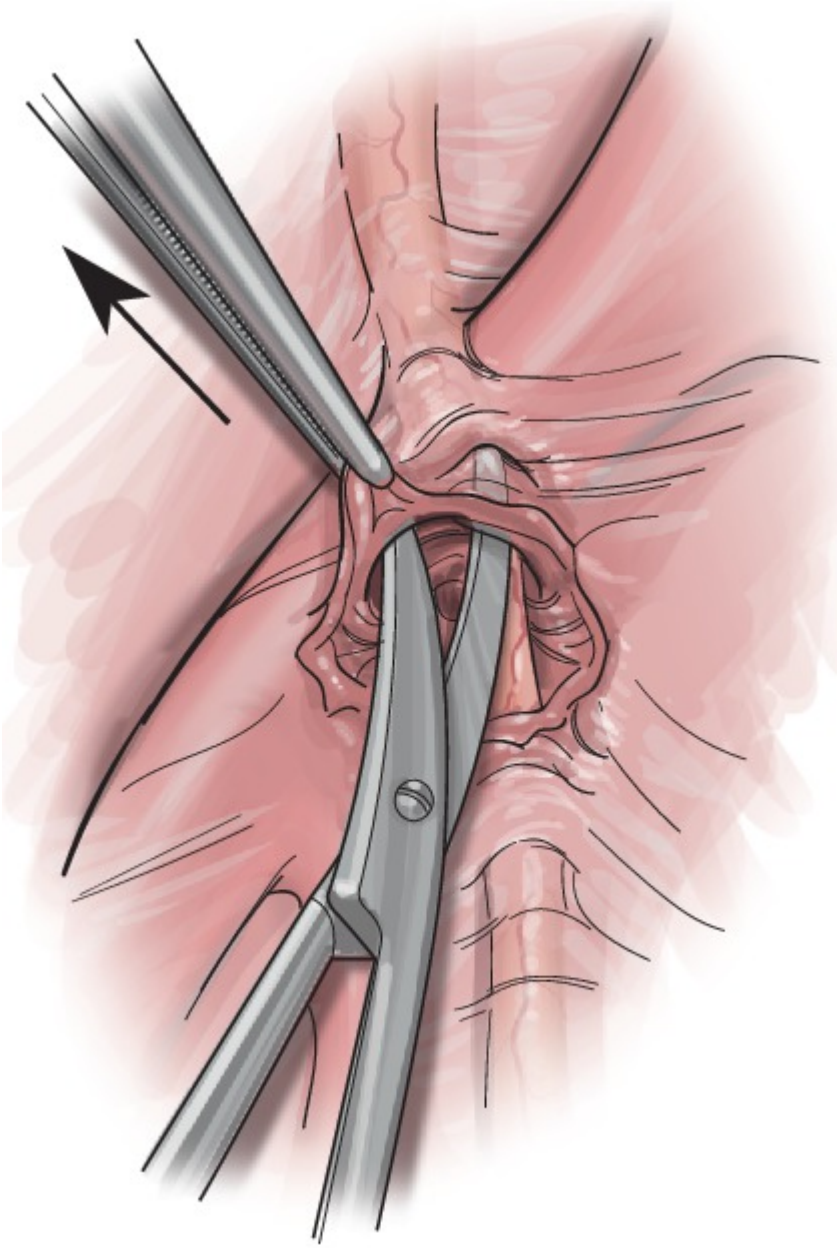


**FIGURE 6.14** Push and spread technique to develop spaces. (Redrawn from Rogers RM, Taylor RH. The core of a competent surgeon: a working knowledge of surgical anatomy and safe dissection techniques. *Obstet Gynecol Clin North Am*. 2011;38(4):777-788.)

## *Traction/Countertraction*

Tissue is gently retracted in opposite directions (**FIG. 6.15**). This can be performed by pulling on the edges of an incision in opposing directions or after a space has been partially dissected using two longer dissecting instruments, such as forceps, to gently lever the tissue opened. Often, simple traction at right angles to a plane of tissue can allow loose areolar tissue to separate. This is useful for identification of small perforating vessels that traverse a space so that they can be cauterized.

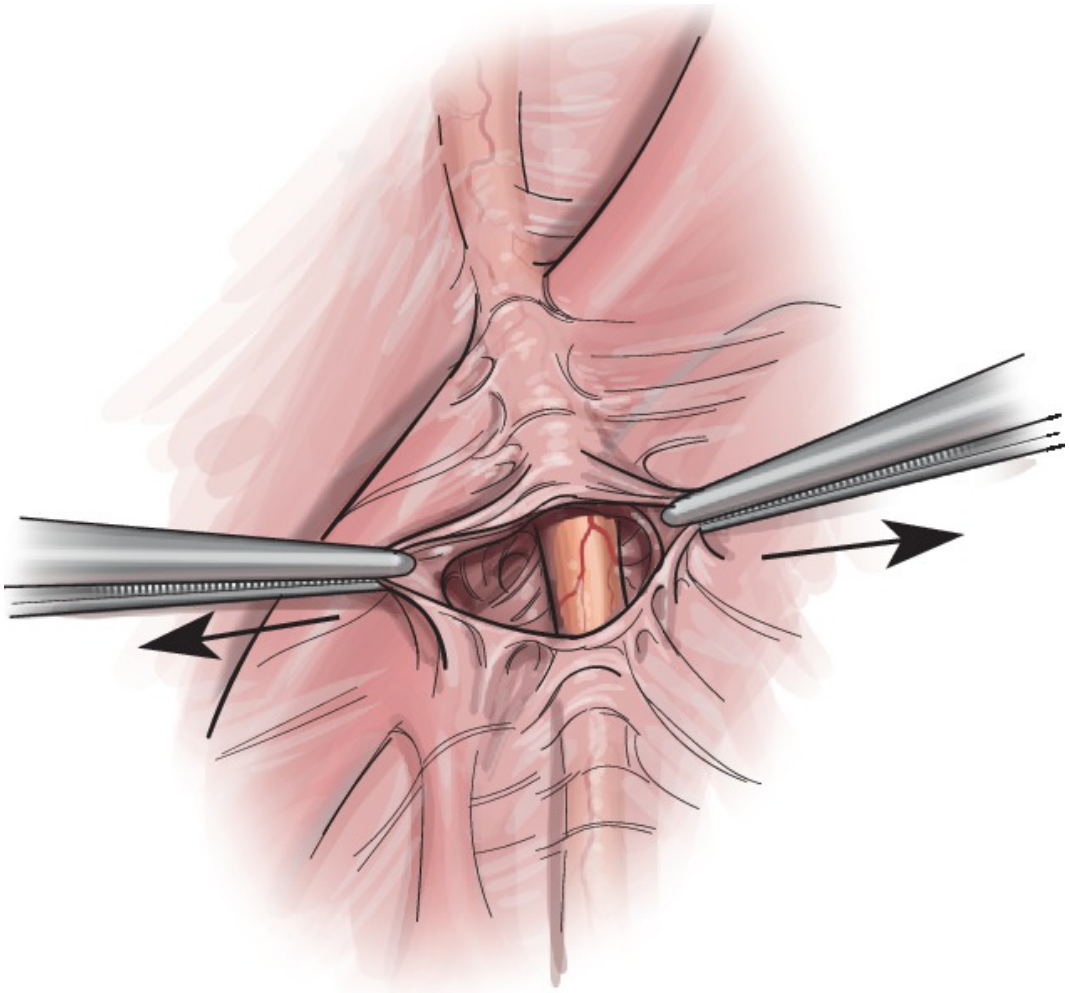


**FIGURE 6.15** Traction/countertraction technique to spread tissue. (Redrawn from

Rogers RM, Taylor RH. The core of a competent surgeon: a working knowledge of surgical anatomy and safe dissection techniques. *Obstet Gynecol Clin North Am*. 2011;38(4):777-788.)

## Rubbing/Wiping

A dissecting instrument can be pushed across a plane of visceral fascia to develop a potential space (**FIG. 6.16**). A Kitner “peanut” or sponge stick can develop the vesicovaginal space in this manner. If the tissue is densely adherent to the fascial plane, the tissue can be dissected away from the plane using small snips with scissors parallel to the tissue plane to advance the dissection millimeter by millimeter until rubbing/wiping maneuvers can be used.

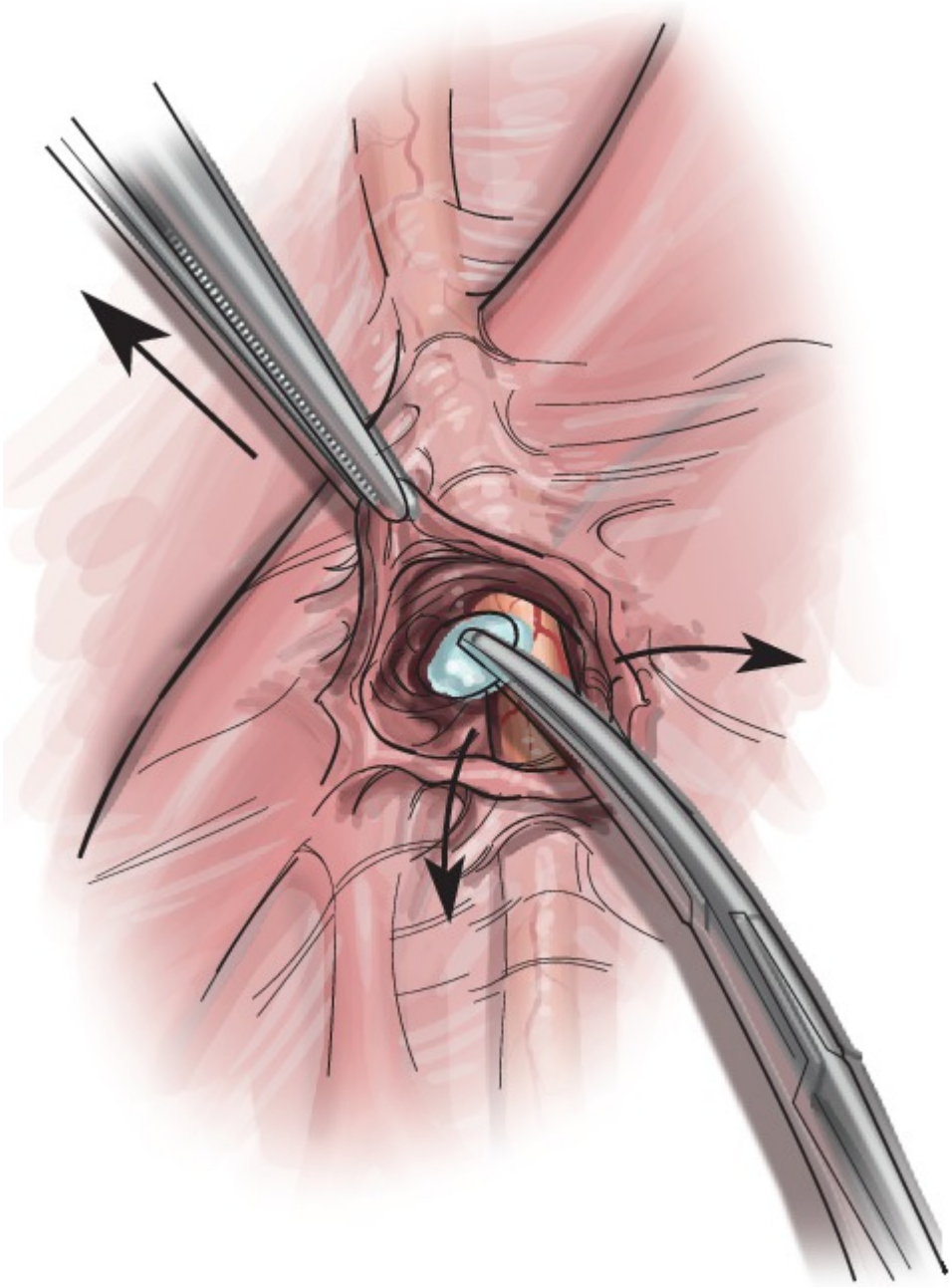


**FIGURE 6.16** Rubbing/wiping dissection illustrated with closed scissors. (Redrawn from Rogers RM, Taylor RH. The core of a competent surgeon: a working knowledge of surgical anatomy and safe dissection

techniques. *Obstet Gynecol Clin North Am*. 2011;38(4):777-788.)

Often, these techniques are performed in combination, for example, using the tips of scissors to dissect a space using initially the push and spread technique and then applying gentle traction within the space that has been opened to further enlarge the space. Repeated experience allows the surgeon to recognize the characteristics of tissues both by visual and tactile input.

## Hydrodissection

A potential space is flooded with saline or a similar fluid using hydrostatic pressure to open a space. This is most often used to develop retroperitoneal spaces during laparoscopic surgery by some surgeons but is also used to elevate the anterior or posterior vaginal tissue during anterior and posterior repairs.

# EXPLORATION OF PELVIC RETROPERITONEUM

Basic knowledge of the surgical anatomy of the pelvis is required to perform major gynecologic procedures, such as hysterectomy or oophorectomy, including the location and boundaries of the major retroperitoneal spaces and anatomic relationships of vital structures at various levels in the pelvis (**FIG. 6.17**). The intraperitoneal anatomy is often distorted, and retroperitoneal dissection is the only way to establish crucial anatomic relationships.

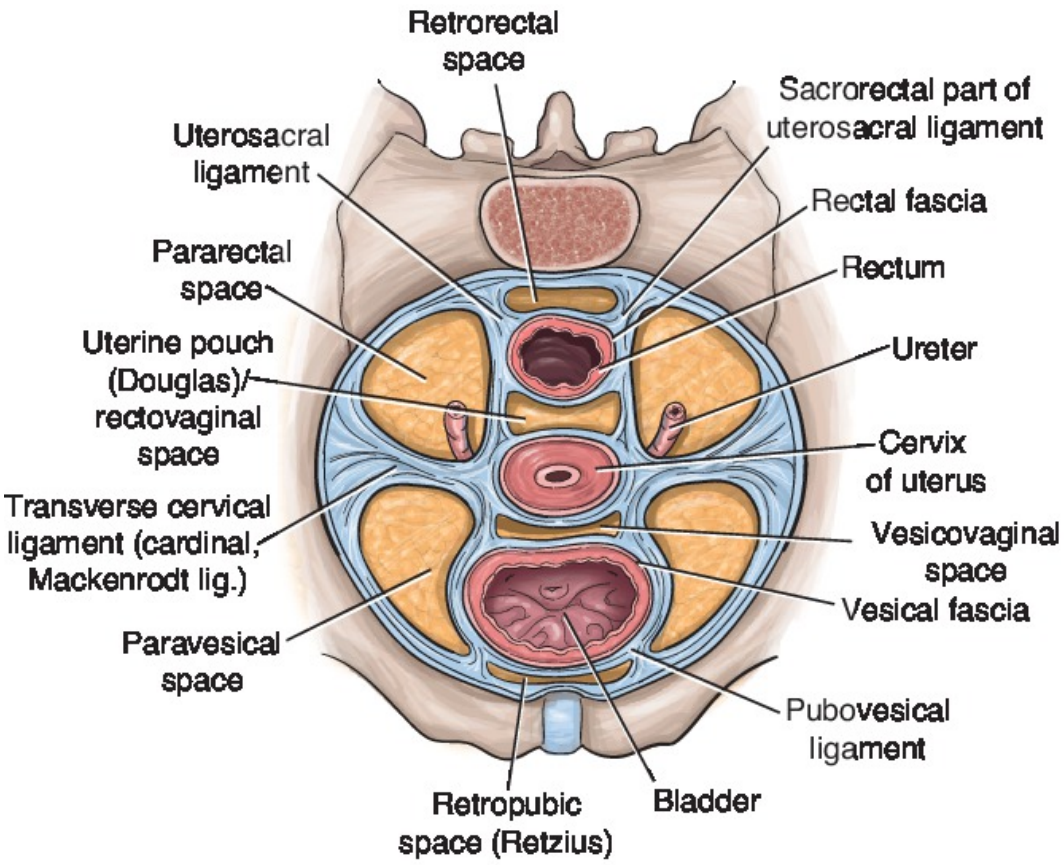



**FIGURE 6.17** Relationship of avascular pelvic spaced and major anatomic structures.

# Dissection of the Pelvic Brim and Pararectal Space

The ureter migrates posterior to the infundibulopelvic (IP) ligament medially, and the common iliac artery divides into internal and external iliac arteries immediately lateral at the pelvic brim. Isolation of the IP from the ureter and sidewall vessels is important when performing oophorectomy, especially when anatomy is distorted by inflammatory process, endometriosis, or tumor.

At the pelvic brim, there are three main surgical layers encountered when dissecting from medial to lateral: medial leaf of broad ligament with ureter and its periureteric visceral sheath attached, internal iliac vessel and anterior tributaries with lymphatics, and external iliac vessels and lymph nodes (**FIG. 6.18**). The obturator nerve and vessels are posterior to the external iliac vessels, just medial to the psoas (anterior) and obturator muscles.

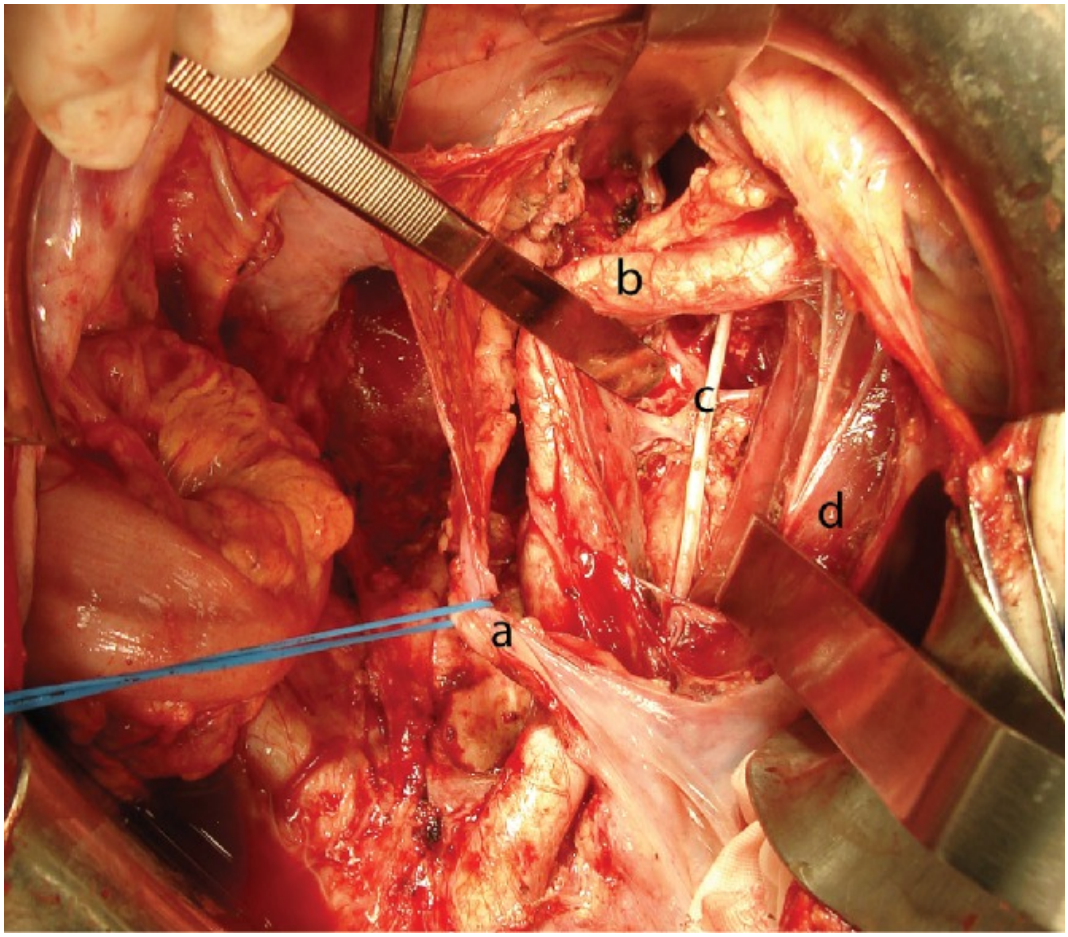



**FIGURE 6.18** Right-sided dissection of pararectal and paravesical space. *a,* Right ureter; *b,* right external iliac after; *c,* obturator nerve; *d,* fat in right obturator space. (Reprinted with permission from Wexner SD, Fleshman JW. *Colon and Rectal Surgery: Abdominal Operations*. 2nd ed. Wolters Kluwer; 2018. Figure 41.3.)

The most reliable technique to identify the ureter is to open the retroperitoneal space by incising the posterior leaf of the broad ligament lateral and parallel to the fallopian tube and infundibulopelvic ligament. This peritoneal incision can be extended

up the paracolic gutter lateral to the colon. Use of traction/countertraction with placement of the majority of pressure against the plane of the medial leaf of the broad ligament will open into the retroperitoneal space. Traction at right angles to sidewall vessels is the most efficient method for developing the pararectal space. It is most efficient to initially locate the ureter at the pelvic brim, rather than initially trying to identify it deep in the pelvis as it travels to the ureteric tunnel. The ureter enters the pelvis within 1 cm of the bifurcation of the common iliac artery and travels medially and posteriorly as it descends to the bladder. The pararectal space can be opened lateral to the internal iliac artery, allowing visualization of the entire pelvic ureter until it enters the ureteric tunnel. Ureteral peristalsis should be observed to confirm the identity of the structure.

In obese patients, large amount of retroperitoneal fat may appear to make visualization of retroperitoneal structures difficult. It is important to realize that much of the fat is contained in the lymphatic tissue and enveloped in the thin visceral fascia. Start by opening the broad ligament laterally and identify the psoas muscle lateral to the vessels. Often, lifting the infundibulopelvic ligament, with traction against the inner surface of broad ligament just below the ovarian vessels, will allow the space to open up. Alternatively, one can dissect medially with push/open and traction techniques over the fatty bundle that overlays the vessels and then alter the direction of dissection from lateral to medial orientation to an anterior to posterior orientation to enter into the upper pararectal space.

Mobilization of the ureter is sometimes necessary. The objective is to dissect the ureter without stripping the periureteral tissue from a long segment that would devascularize a long portion of the ureter. The medial leaf of the broad ligament should be grasped and lifted above the ureter. Using push and spread technique, dissect at right angles to the ureter until a short segment is mobilized. If dense fibrosis involves the ureter, initiate dissection away from the densest region of fibrosis. To avoid crushing the ureter, grasp periureteral tissue rather than the ureter itself. Malleable retractors, vessel loops, or other instruments should be used to retract the ureter rather than grasping it for prolonged periods of time.

# Ligation of the Internal Iliac (Hypogastric Artery Ligation) and Uterine Arteries

Ligation of the hypogastric artery, also called the internal iliac artery, is sometimes performed to control surgical and postpartum hemorrhage. The internal iliac vein lies lateral and slightly posterior to the internal iliac artery. There is marked variability in its course, location, and branches of the hypogastric venous plexus. When attempting to ligate the hypogastric artery, open the paravesical space lateral to the superior vesical artery and medial to the external iliac vessels. Clear areolar tissue off of the lateral aspect of the superior vesical artery and trace the course of the artery retrograde to the pelvis. Place the artery on tension and trace distal to proximal. Using a right-angle clamp, push/spread from the anterior to posterior surface to isolate the internal iliac artery distal to where it crosses the internal iliac vein, and then pass suture for ligation. Dissection in this direction is less likely to lacerate the internal iliac venous plexus compared to dissection from posterior to anterior. Two absorbable sutures are usually passed and then tied, and the artery is not divided. For more details of the procedure, see Chapter 39 and Figure 39.3.

Isolation of the uterine artery and cardinal ligament lateral to the ureter is required for radical hysterectomy and useful for controlling the blood supply of the uterus during debulking procedures or when the posterior cul-de-sac is obliterated with endometriosis. The cardinal ligament is composed of the vessels and parametrial tissue deep to the uterine artery. This is the “web” of tissue between the pararectal and paravesical spaces. The distal superior vesical artery should be isolated lateral to the bladder after opening the paravesical space. This can then be placed on traction parallel to the external iliac vessels. The uterine artery can be identified by carefully dissecting retrograde along the superior vesical artery into the pelvis. Suture can be passed around the uterine artery and tied, or the arterial pedical can be suture ligated (**FIG. 6.19**). See Chapter 39 for additional discussion.

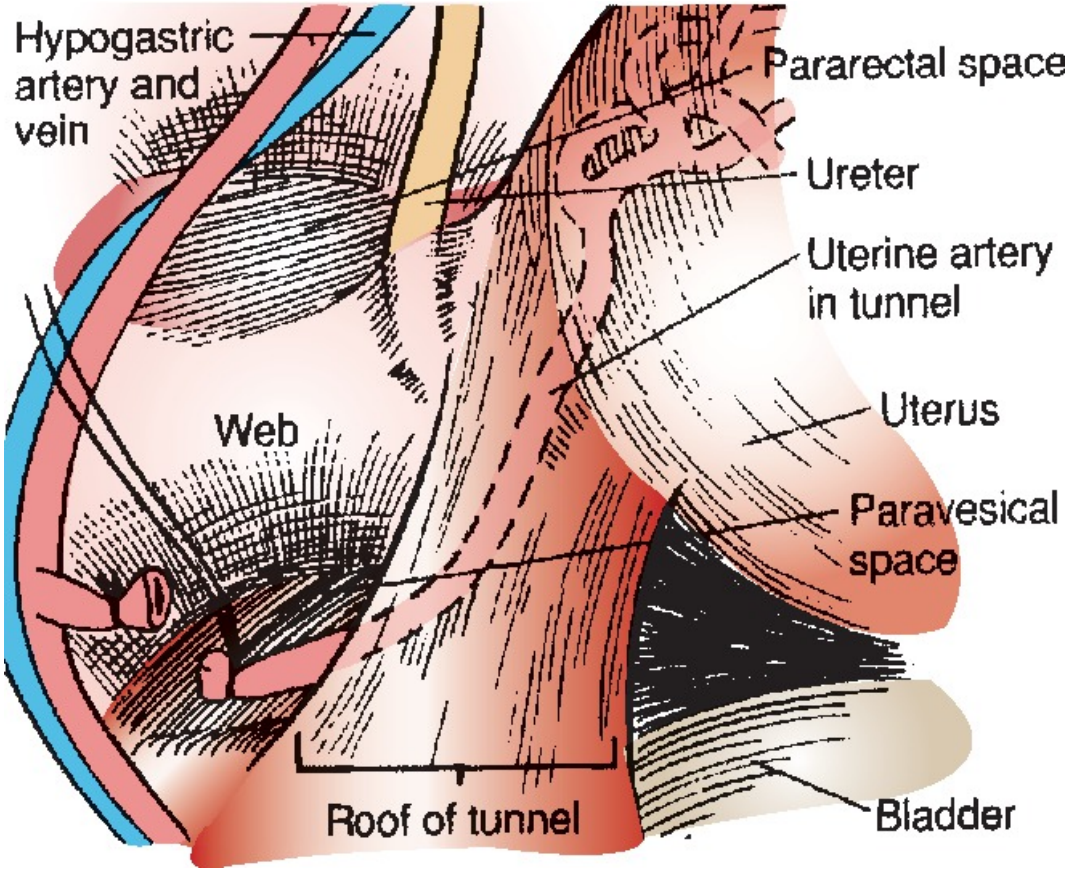



**FIGURE 6.19** Anatomic structures in the paravesical and pararectal lateral spaces of the pelvis. (Reprinted with permission from Jaffe RA, Schmiesing CA, Golianu B. *Anesthesiologists Manual of Surgical Procedures*. 5th ed. Wolters Kluwer Health; 2014. Figure 8.1.9.)

# Dissection of the Presacral Space

The upper extent of this space is entered during sacral colposuspension procedures and for presacral lymph node harvesting. In actuality, this begins as a lower “prelumbar” space. Sometimes, the deeper presacral space is entered and dissected to the level of the coccyx to help mobilize the rectosigmoid colon for difficult dissections or during *en bloc* resection during gynecologic cancer debulking surgeries (see Chapter 1 for presacral space anatomy).

To enter this space, the sigmoid colon is reflected to the left, and the peritoneum above the sacral promontory is opened to the right of the colon at or above the level of the right common iliac artery. When dissecting in this space care must be taken to avoid injury to the right ureter. Traction/countertraction and push-spread techniques are used to initially elevate the peritoneum anteriorly. This will expose the bifurcation of the aorta and common iliac veins. Avoid aggressive posterior dissection because the middle sacral artery and vein descend from the junction of the common iliac vessels and course just anterior to the anterior ligament of the lowest lumbar vertebrae and sacral promontory, coursing down the hollow of the sacrum. Disruption of the perforating veins feeding into the middle sacral vein can result in bleeding that is difficult to control, because the severed veins may retract below the level of the periosteum.

The areolar tissue between the sacrum/vessels and the mesentery of the distal sigmoid/rectum can be opened further, extending below the uterosacral ligaments to the tip of the coccyx. During dissection, the majority of gentle dissection is directed anteriorly, to elevate the distal sigmoid and proximal rectum from the anterior ligament of the sacrum.

# Dissection of the Space of Retzius or Retropubic Space

Development of this space (**FIG. 6.17**) is the key to retropubic suspension procedures, mobilization of the bladder for ureteral reimplantation, and pelvic exenterations requiring removal of the bladder. The peritoneum cephalad to the bladder is opened, and gentle dissection should be performed along the surface of the pubis, initially in the midline. Avoid trauma to prominent bilateral vascular plexus along and lateral to the urethra and the base of the bladder. The dissection is usually continued below the neck of the bladder and exposes the endopelvic fascia lateral to the urethra. The dissection can mobilize the entire length of the urethra if cystectomy is to be performed.

# Dissection of the Paravesical Space

There are two approaches to the paravesical space: (1) dissecting laterally from the developed space of Retzius most frequently employed during paravaginal repair and (2) transperitoneally after opening the middle leaf of the broad ligament, most frequently used during radical hysterectomy or pelvic lymphadenectomy.

When dissecting from the space of Retzius, the superior vesical artery is anterior to the space. Gentle spreading opens the space, initially following the concave curve of the superior and inferior rami of the pubis. As the space develops, the anterior portion of the vagina is retracted posteriorly and slightly to the opposite side. The levator plate will be encountered along the posterior ramus. Dissecting along the levator muscle will allow exposure of the levator tendon, well below the obturator nerve and sidewall vessels.

The transperitoneal approach begins by dividing the round ligament just medial to the external iliac vessels and opening the broad ligament anterior and posterior to the round ligament. Most often, a ridge can be identified arcing onto the inner wall of the abdomen lateral to the bladder. This is the continuation of the superior vesical artery. It can be grasped through the peritoneum and retracted medially, which will partially open the space. In an obese patient, this landmark may not be able to be identified. In these cases, spreading the areolar tissue just medial to the fatty lymphatic tissue adherent to the distal external iliac vessels will begin to open the space. Spreading with medial traction against the superior vesical artery will usually yield the most efficient dissection. Fatty tissue adherent to the superior vesical artery can be dissected directly off of the artery. The deep dissection is continued until the levator plate is identified and posteriorly until the external iliac vessels and internal iliac artery are exposed.

# Retained Surgical Instruments

A retained surgical instrument or surgical sponge is a dreaded event for any surgeon. Although the true incidence is difficult to determine due to underreporting, it is estimated that these occur in one in eight

thousand to one in fifteen thousand cases. A Joint Commission Study of 308 cases of unintentional retained foreign objects (URFO) reported that Obstetrical or Gynecological procedures accounted for 25.9% of all reported URFO events. At least 156 cases occurred during minimally invasive procedures, with the most frequently retained object comprising parts of a uterine manipulator or off-label use of items such as a glove filled with sponges or Asepto bulb used in the vagina to maintain pneumoperitoneum.

For the patient, the majority of these were discovered within the first 10 days after the event, but almost half were only discovered after discharge. The complications reported in the Joint Commission study ranged from bothersome to life threatening, with 68.5% of patients experiencing additional care or an extended hospital stay and 20.4% of patients experiencing significant morbidity or mortality. For the surgeon, these are reportable events and will impact their professional standing, licensing, and certification. For hospitals, retained instruments will impact their rating and are also reportable to major organizations such as Joint Commission and Centers for Medicare Services.

Among 219 cases of URFO analyzed by the Joint Commission, the root cause was a breakdown in communication during the procedure. In the event of an incorrect instrument or surgical sponge count, the surgeon must stop the procedure and work with the team to correct the count and find the missing object. This involves a search of the surgical field, linens, trash, and may involve radiographs. Many surgical sponges contain a tag that can be detected by an X-ray and a radiofrequency (RF) detector. An RF wand can be used to scan the operative field to detect retained sponges prior to completion of closure. The costs due to retained surgical instruments often range over $100 000. Risk factors for retained surgical instruments include obesity, prolonged operating time, cases that involve multiple surgical teams, and change in operating room personnel. Because an incorrect count is often the first notification that instruments or sponges are missing, it is paramount that the surgeon works with the operating room team to locate the missing object before completing the procedure and initiating closure.

# KEY POINTS

- Low lithotomy position is ideal for most open pelvic procedures. It allows a second assistant standing between the patient's legs to improve access to the operative field. There is ready access to the vagina and anus for difficult dissections where placing a sponge stick in the vagina or probe into the rectum can aid in identification of these structures. Furthermore, the patient is in position for cystoscopy if identification of ureteral patency or ureteral stenting is needed.
- Good lighting on the operative field is vital for any surgical procedure. Overhead lights should be placed where they are not obstructed by the surgeons' heads and may need to be dynamically shifted during the procedure. A headlight is useful for illuminating deep pelvic surgical fields.
- Long open surgeries can be physically exhausting. The most ergonometric posture will avoid unnecessary strain and fatigue during a single procedure and ultimately over the career of a pelvic surgeon. The surgeon's back should be straight, shoulders back, and feet slightly spread at shoulder width with weight distributed evenly between the feet.
- The operating table should be at a height where the patient's abdominal surface is slightly below belt level. This allows a panoramic view into the pelvis and the surgeon's arms are at her sides, extended slightly >90° at the elbows. If the table is much higher, the surgeon will be lifting her elbows, putting strain on her shoulders, and expending energy during surgery.
- During a long procedure, it is not uncommon to discover that poor exposure of the operating field has required contortions of posture to view critical structures or retract adjacent tissues. The surgeon should be aware of these situations and adjust their posture intermittently to avoid strain in the upper and lower back.
- Surgical knots are an important component of the surgeon's skill set. Although a seemingly mundane skill, it is important to

practice knot tying with a variety of suture materials and tie knots efficiently and confidently.

- Basic knowledge of the surgical anatomy of the pelvis is required to perform major gynecologic procedures, such as hysterectomy or oophorectomy. It is important to know the location and boundaries of the major retroperitoneal spaces and anatomic relationships of vital structures at various levels in the pelvis.
- Communication among members of the operating team is vital to avoid the complication of retained surgical instruments and surgical sponges.

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# CHAPTER 7

# PRINCIPLES OF ELECTRICAL AND LASER ENERGY APPLIED TO GYNECOLOGIC SURGERY

Magdy P. Milad and Ted L. Anderson

**History and the Development of Electrosurgery**
**Basic Principles of Electrosurgery**
**Electrosurgical Units (Generators)**
Electrosurgical Unit Output
Dispersive Electrodes (“Return Pads”)
**Electrosurgical Circuits, Waveforms, and Tissue Effects**
Monopolar vs Bipolar Circuits
Continuous vs Interrupted Waveforms
Tissue Effects
**Safety Concerns With Monopolar Circuits**
Open Activation
Direct Coupling
Insulation Failure
Capacitive Coupling
Active Electrode Monitoring
**Argon Beam Coagulator**

**Bipolar Instruments**
First Generation
Second Generation
**Electrosurgical Applications in Operative Hysteroscopy**
Monopolar
Bipolar
**Ultrasonic Technology**
**Laser Technology**
Historical Perspective and Background
Principles of Laser Technology
Types and Applications of Lasers
Laser Safety
**Special Surgical Situations**
Pregnancy
Body Piercing and Prosthetic Implants
Implantable Devices
**Hazards of Electrosurgery in the Operating Room**
Fire Hazards
Surgical Plume

Since the late 1800s, the practice of medicine and surgery has increasingly relied on applications of energy. Indeed, most gynecologic surgical procedures performed today incorporate some form of applied energy. Unfortunately, the typical resident or fellow graduating from an obstetrics and gynecology program has received limited formal training concerning the principles and application of electrosurgery. Consequently, many gynecologic surgeons do not fully understand the underlying physical principles that govern the

desired biologic effects or do not understand how to manipulate settings and techniques effectively to achieve them. These limitations in a surgeon's knowledge of electrosurgical principles can permit delivery of unintended energy, potentially resulting in immediate or delayed complications.

Over the past three decades, electrosurgical instruments and generators have evolved into complex systems that can interact with tissue to modulate, limit, and even discontinue energy delivery in response to rapid changes in tissue impedance. In some cases, a variety of energy modalities can be delivered by the same instrument. To use these devices and systems effectively and safely, it is imperative that the contemporary gynecologic surgeon has a working knowledge of energy generation, delivery, and tissue effects.

Our goal in this chapter is to provide the fundamental principles of electrosurgery and laser technology. More specifically, we wish to provide a practical approach that illustrates how these are applied within the field of gynecologic surgery to promote safe use of the available instruments.

# HISTORY AND THE DEVELOPMENT OF ELECTROSURGERY

As early as the 4th century BC, the Egyptians described the treatment of wounds using a device called a "fire drill," which turned rapidly to produce heat along its shaft. In the early writings of the Hippocratic Corpus (~400 BC), followers of Hippocrates described the treatment of various tumors, as well as hemorrhoids, through direct application of heat. During this period, the use of heat was frequently accomplished through specific heating of a metal device and placing it directly on the wound, essentially inflicting third-degree burns without the ability to modulate tissue effect. Accordingly, the word "cautery" arose from the Greek term *kauterion*, meaning "hot iron." Around 1600, the English physician and scientist William Gilbert introduced the term *electricus* meaning "like amber" as he discovered attraction of objects to each other after rubbing them against an amber rod. Once electricity was widely available, this

concept was further expanded to “electrocautery,” describing the use of electricity to heat the metal tip of a device and subsequently apply direct heat to the tissue.

It was Benjamin Franklin’s 18th-century experiments with electricity that led to the idea that direct application of electrical current to tissue might be used to advantage in medicine. While John Wesley (England), Johann Kruger (Germany), and Jean-Antoine Nollet (France) experimented with paralytic conditions, Franklin and his Dutch colleague Jan Ingenhousz described a “highly elated state” after several unintended nonlethal shocks to the head and proposed this therapy for melancholy.

Two significant discoveries paved the way for modern application of electricity in medicine. First was the recognition of electromagnetic induction by Michael Faraday and Robert Todd, leading to the ability to harness and store electrical energy reliably. This gave rise to a pathway for development of electrosurgical generators. The second was an extension of the work of Luigi Galvani, who demonstrated that electricity applied to frog legs induced muscle contraction. William Morton and Arsenne D’Arsonval recognized that application of electricity at a frequency of >100 kHz allowed electricity to pass through the body without inducing pain or burn and without inducing muscle (including cardiac) spasm, the so-called Faradic effect. D’Arsonval further noted that the current directly influenced body temperature, oxygen absorption, and carbon dioxide elimination, increasing each as the current passed through the body. Of note, the temperature was determined to increase proportionally to the square of the “current density.”

The French surgeon Joseph Rivière in the early 1900s was perhaps the first to use electricity clinically, in the form of an electrical shock to treat a hand ulcer. However, in the 1920s, it was Grant Ward who demonstrated that a continuous sinusoidal electrical waveform was superior for cutting tissue and an interrupted electrical sinusoidal waveform resulted in more effective coagulation. This led to the now infamous collaboration between neurosurgeon Harvey Cushing and physicist William Bovie to produce an electrosurgical unit (aka generator) designed to achieve intraoperative hemostasis during neurosurgical procedures. They published the results of a

case series of intracranial tumor excisions in 1928, with an excerpt by Dr. Bovie describing the principles of superficial dehydration (desiccation), cutting, and coagulation as they applied to the tissue. These landmark events led to the era of modern applications of electricity in medicine. Unfortunately, Bovie was chastised for his invention and told that only a charlatan would use electricity during surgery. Ultimately, Bovie sold the patent for 1 dollar and died a penniless man.

# BASIC PRINCIPLES OF ELECTROSURGERY

Electrocautery and electrosurgery are not synonymous. *Electrocautery* refers to the application of direct current through a wire to produce heat; the wire is then applied directly to tissue to create the desired thermal effect. Thus, in electrocautery, the patient tissue is not involved in the electrical circuit. A common use of electrocautery is in the emergency department to relieve subungual hematomas. Electrocautery units are not commonly used in a traditional operating room.

Conversely, *electrosurgery* is the employment of kinetic energy in the form of alternating current (AC) radiofrequency (RF) transferred into tissue, raising intracellular temperature. In electrosurgery, the patient tissue is included in the circuit. The energy can be modulated to achieve desired tissue effects.

There are three specific required elements in electrosurgery. First, there must be an electrosurgical unit or generator to modulate electricity delivered from the wall outlet of the operating room (50-60 Hz) to a much higher frequency (>200 000 Hz) and deliver it in the required conformation. Second, there must be an active electrode to deliver electricity to the tissue of interest in the form required. Third, there must be a return or dispersive electrode to complete the electrical circuit.

The flow of electricity to and from an electrosurgical unit through tissue follows the basic principles of physics. Alternating current forces particles of energy (*electrons*) through tissue between

negatively and positively charged poles, with rapid reversal of direction. The term *circuit* is used to describe the path the electrons take. In electric circuits, electricity is typically carried through conductors (such as wire) but can also be carried through living tissue. Electron flow through cells creates changes in polarity of the cellular electrolytes ($Na^+$, $Ca^{++}$, $K^+$, $Cl^-$, etc.). Electromagnetic energy causes the anions to migrate toward the positive electrode and cations toward the negative, which is referred to as the galvanic effect. Importantly, the high-frequency flow of electrons in the RF spectrum surpasses that required for cellular membrane depolarization (100 kHz) and does not affect the opening of sodium or calcium channels. Rather, the frictional forces of these charged intracellular ions create kinetic excitation and subsequent intracellular thermal heating as a result of thermodynamic changes.

The flow of electrons through a conductor is called *current*, which is governed by two opposing forces, namely, *voltage* (the force pushing electrons along a circuit) and *impedance* (opposition to the free flow of electrons). This relationship is defined by Ohm law, which is depicted in **FIGURE 7.1**. You can see from this relationship that to increase electron flow (current), you must either increase the electromotive force (voltage) or decrease the impedance to free flow. Some find it helpful to think of this in terms of water flowing through a hose in your garden. If you kink the hose (increase impedance), your water flow (current) is going to decrease. The only way to accommodate for this is to increase the water pressure (voltage) proportionally. For the remainder of the chapter the term impedance will be used to refer to the nature of opposition of the AC electricity in contrast to resistance, which is employed when discussing direct current.

$$\underset{\text{(amps)}}{\text{Current } (I)} = \frac{\text{Voltage } (V) \text{ (volts)}}{\text{Resistance } (R) \text{ (ohms)}}$$

**FIGURE 7.1** Ohm law describes the flow of electrons through a circuit.

We can further explore the relationship between impedance and voltage by examining the concept of *power*, defined as the instantaneous energy required per unit time to perform a function, measured in watts. Specifically, power is defined by the electromotive force (voltage) times the flow of electrons (current), or $W = V \times I$. With mathematical substitution of Ohm law ($I = V/R$), we can derive that power (watts) is related to the voltage squared, divided by impedance, or $W = V^2/R$. In practical terms, this means that as impedance increases, to maintain the power required to perform a function, the voltage also increases. Importantly, it is the voltage that we must harness and control to accomplish electrosurgical tasks effectively and safely. If we go back to our hose analogy, this means that if you increase impedance (kink the hose), to maintain the watts or instantaneous energy required per unit time to perform a function of work (to water the garden), the voltage (water pressure) must increase. Therein, we have the basic mathematical and physical basis for applied electrosurgery.

# ELECTROSURGICAL UNITS (GENERATORS)

## Electrosurgical Unit Output

Current is delivered between the electrosurgical unit and tissue in the surgical field by an electrosurgical instrument (“active” electrode) at a frequency between 200 000 and 3 million Hz. These frequencies represent a portion of the RF spectrum. This range includes frequencies used in common household appliances (60 Hz) through broadcast television ($10^8$ Hz), microwave ($10^{10}$ Hz), and gamma rays ($10^{24}$ Hz), as depicted in **FIGURE 7.2**. Frequencies below 100 000 cycles per second can cause tetanic muscle contraction (Faradic effect). Rarely during the use of electrosurgery, muscle twitches or nerve stimulation can occur from demodulation of current frequency to below 100 000 Hz, presumably by multiple circuit pathways interacting within the biophysical environment.

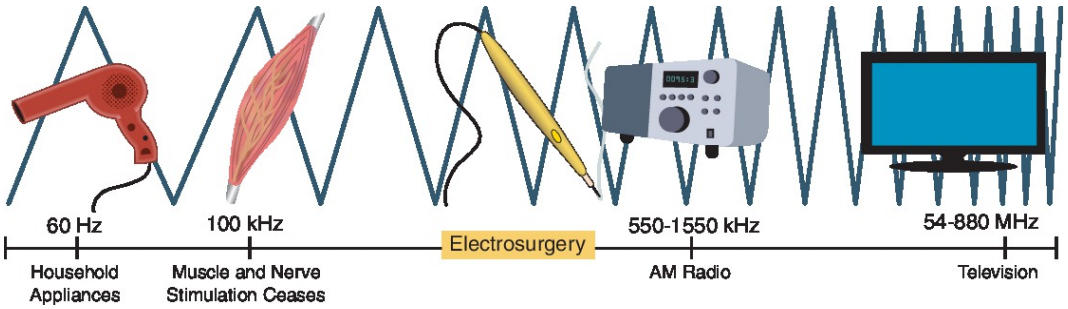


**FIGURE 7.2** RF spectrum. The frequency produced by electrosurgical generators overlaps with the range of AM radio waves and is thus referred to as “radiofrequency” (RF).

Most modern solid-state electrosurgical units can produce over 8000 V. However, most outputs in typical use are in the 500-3000 V range with a frequency upward of 500 000 Hz. Further, most generators today are calibrated to power output, with the power that is set by the surgical staff reflecting the power available at the start of the electrosurgical application. As tissue impedance increases with heating in response to applied energy, we know from our prior calculations that power decreases. Additionally, many modern electrosurgical units are best described as adaptive generators. Often designed to work in concert with specific instruments, they can adjust computer-controlled output in real time. They measure tissue impedance at the operative site and modulate output accordingly. Additionally, electrosurgical units generally have features for limiting maximum voltage, thereby reducing unintended effects of “stray energy.”

# Dispersive Electrodes (“Return Pads”)

Historically, generators were ground-referenced, which means that the “ground” was part of the circuit. Unfortunately, this allowed the circuit to be completed by circumventing the dispersive pad (sometimes called grounding pad) through alternative pathways to

the ground, creating the opportunity for unintended patient thermal injury at sites such as an EKG lead. Isolated circuit electrosurgical units were introduced in the late 1960s, whereby current delivered by the unit is returned to the unit (not to the “ground”) to complete the circuit. Further, the current delivered to the patient is generated in transformers insulated from the electrosurgical unit frame. Thus, when the electrical circuit is interrupted, the electrons do not seek ground and no current flows. This introduced the concept of “return electrode” rather than “grounding pad,” although the two terms are often (incorrectly) used interchangeably. Technically, even the term “return” electrode is a misnomer, given that current alternates through it at the same frequency and with the same power as the “active” electrode. The term *dispersive electrode* most accurately describes the pad applied to the site remote from the surgical field; it virtually eliminates the risk of injury given its large surface area, which disperses the current. However, if a dispersive electrode is poorly placed, or partially peels off intraoperatively, there may be enough current density at some point of the dispersive electrode to result in a burn.

Return electrode monitoring was introduced in the 1980s and is still used today. In this system, a dispersive electrode consists of two side-by-side conductive surfaces, separated by an insulator, all contained within the same pad (**FIG. 7.3**). Built-in monitors in the electrosurgical unit measure integrity of pad contact with skin through a low-impedance interrogatory current. The impedance between the two pads should remain between 20 and 100 ohms, which is achieved through uniform skin contact. If there is poor contact, an alarm occurs, and generator output is automatically discontinued. The dispersive electrode should remain dry and be placed with the long edge closest to the surgical field, which allows for maximum dispersion of current along the leading edge. Pad sizes vary, including those appropriate for the neonate, pediatric, and adult; the former two have limited power delivery for patient safety.

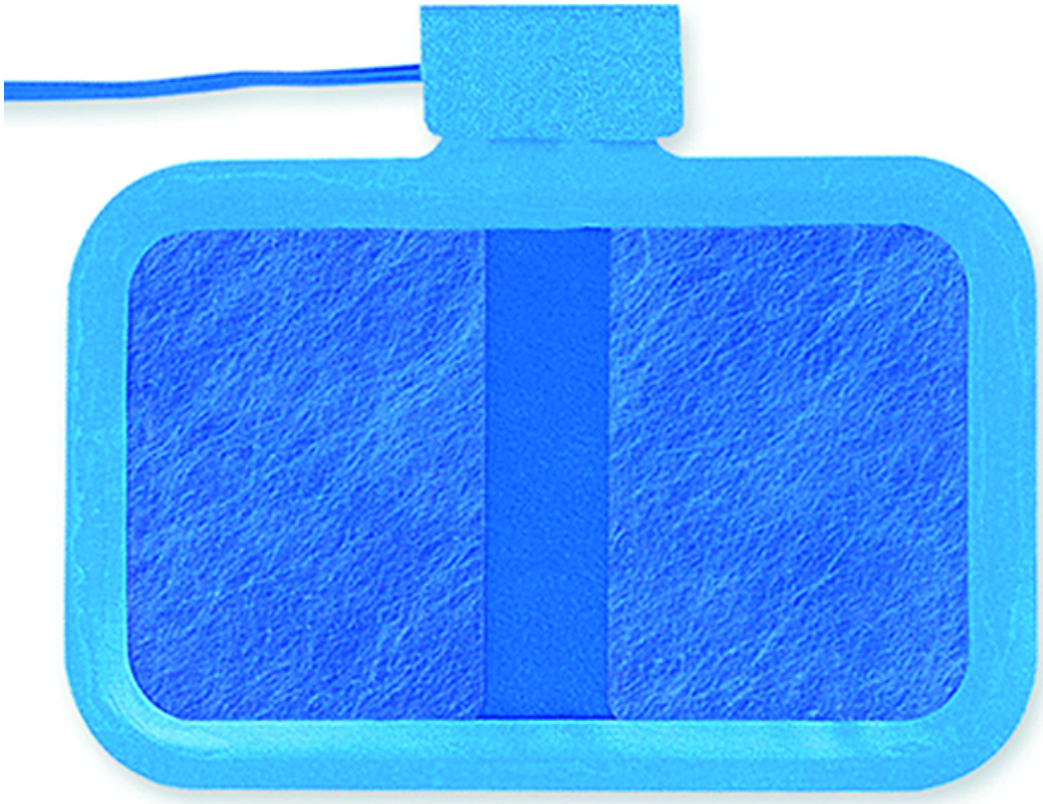

**FIGURE 7.3** The dispersive or “return” electrode is composed of two side-by-side electrodes contained within the pad. An interrogatory circuit determines the impedance between the two and will not allow the generator to activate unless the impedance mimics tissue (20-100 ohms).

# ELECTROSURGICAL CIRCUITS, WAVEFORMS, AND TISSUE EFFECTS

## Monopolar vs Bipolar Circuits

All modern electrosurgical units offer the ability to modulate electrical current with the RF output delivered in *monopolar* or *bipolar* circuits and a continuous or interrupted waveform pattern. By convention, we typically refer to these two patterns as *CUT* and *COAG* (respectively) in homage to the description of tissue effects described by Ward and Bovie in the 1920s. However, the terms CUT and COAG are misnomers as they refer to tissue effects and not to a waveform, which is discussed in detail below. Further, the term *monopolar* current is also a misnomer, as all electrical circuits must technically be bipolar.

The more appropriate distinction between electrosurgical circuits is the location of the active and dispersive electrodes with respect to each other. With monopolar circuits, the active electrode (instrument creating tissue effect) and the dispersive electrode are remote from each other. Thus, the RF energy enters the body through the active electrode and is dispersed through a myriad of routes following the path of least resistance to the dispersive electrode to complete the electrical circuit, alternating in direction thousands of times each second (**FIG. 7.4**). The concentration of RF energy at the active electrode (high current density) is responsible for local tissue effect (eg, burn) at that site. Conversely, the diffused nature of RF energy through the body and at the site of the dispersive electrode (low current density) explains why there is no recognizable effect. Using this principle, the surgeon can modify tissue effects at the active electrode simply by changing the surface area of the instrument used to deliver power (eg, modifying current density by using a standard electrosurgical spatula electrode with the edge vs the wide face of the blade facing the tissue or by using a needle tip electrode) or by altering power settings (**FIG. 7.5**).

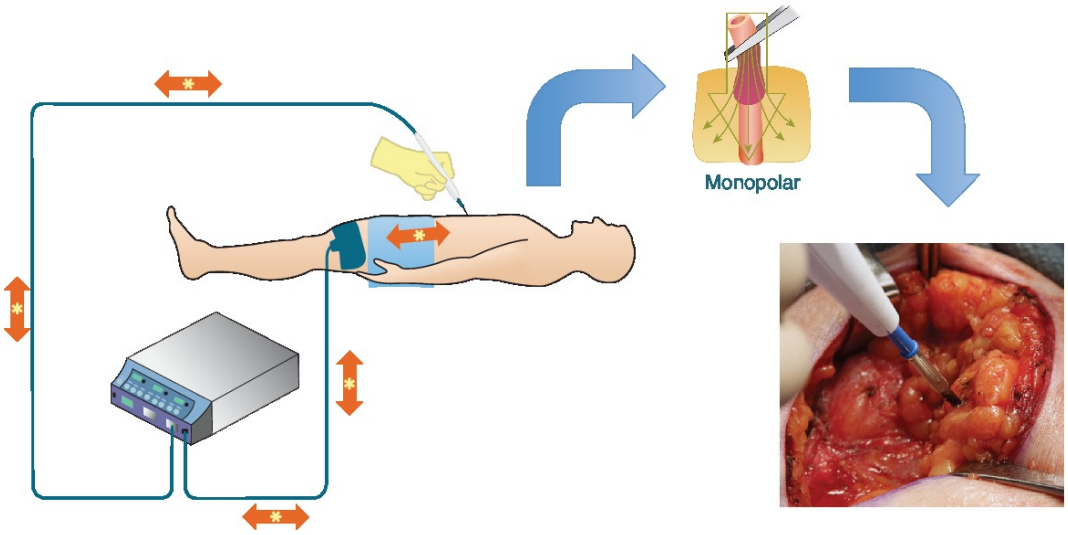


**FIGURE 7.4** Monopolar electrical circuit. RF is delivered from the electrosurgical unit through an active electrode to the patient, is dispersed through the patient, and is returned to the electrosurgical unit via a remotely placed return electrode to complete the circuit.

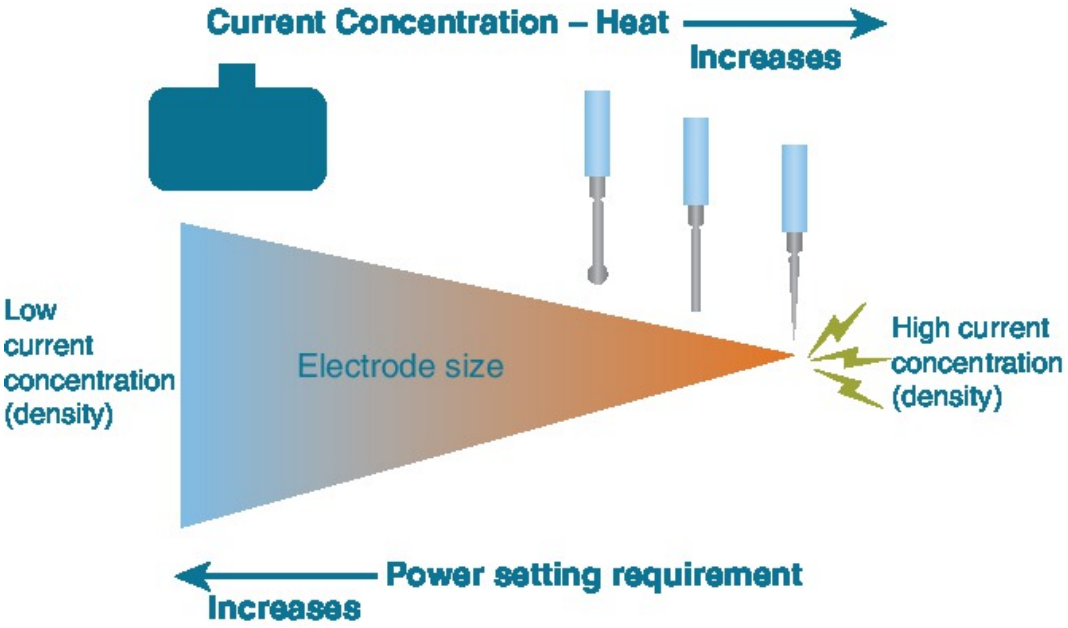

**FIGURE 7.5** Current density. The higher concentration of RF energy at the active electrode is responsible for the tissue effect achieved at that site. Increasing the electrode size decreases charge density and lessens the local effect. Further, as electrical current radiates away from the active electrode, the tissue effect is dramatically decreased.

In bipolar circuits, the two electrodes are components of the same instrument and separated by use of an insulator (eg, ceramic, air). When the bipolar electrodes are of similar surface area, the current density is identical at both electrodes. Importantly, the only part of the patient involved in the bipolar circuit is that tissue directly located between the electrodes (**FIG. 7.6**). Nevertheless, heat can extend beyond the edges of the electrodes, known as lateral thermal spread.

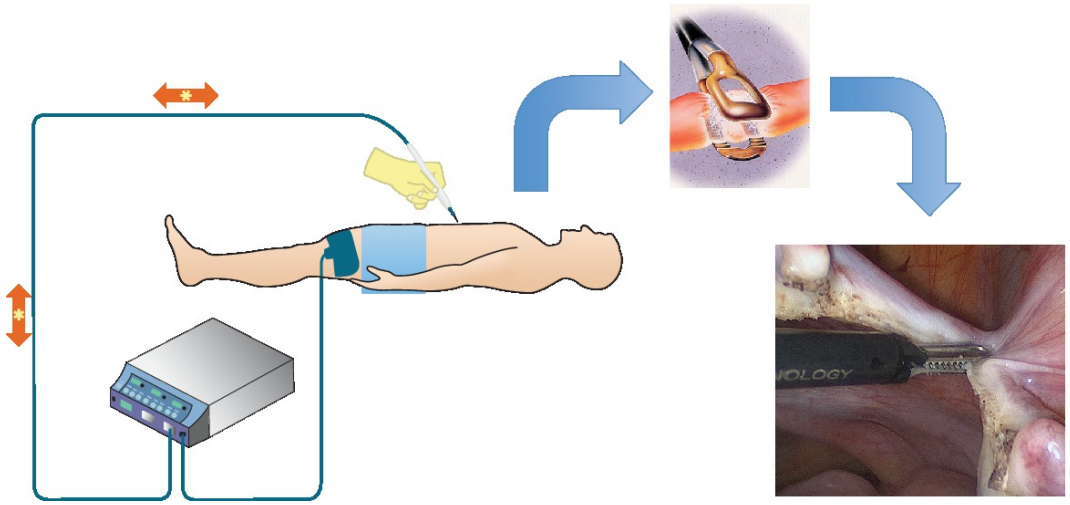

**FIGURE 7.6** Bipolar electrical circuit. RF is delivered from the electrosurgical unit through

an active electrode to the patient and is returned to the electrosurgical unit via dispersive electrode located in the same instrument to complete the circuit. Only the tissue located between the electrodes is involved in the circuit.

## Continuous vs Interrupted Waveforms

In monopolar circuits, RF energy may be delivered either in a continuous (CUT) waveform or in interrupted pulses (COAG) of electrical current. In CUT mode, there is delivery of a continuous uninterrupted sinusoidal waveform through the active electrode (continuous duty cycle). Alternatively, in COAG mode, the RF energy is delivered in pulses whereby over a given time energy is only delivered ~6% of the time (interrupted duty cycle). During the resting phase, desiccated, cooled, and coagulated tissue with denatured proteins increases impedance and thus increases voltage required for continued energy delivery. Most electrosurgical units offer a "BLEND" mode in which the duty cycle is altered, ranging from 40% to 80%, allowing for a mixture of cutting and coagulation properties (**FIG. 7.7**). It is important to note that when using a blend mode, the power delivered is based on the CUT setting. For example, if the CUT setting is 60 W and COAG setting is 40 W, a 50% BLEND would deliver 60 W for 50% of the time and 0 W for the remaining 50% (ie, the COAG setting has no impact on the energy output when BLEND is selected).

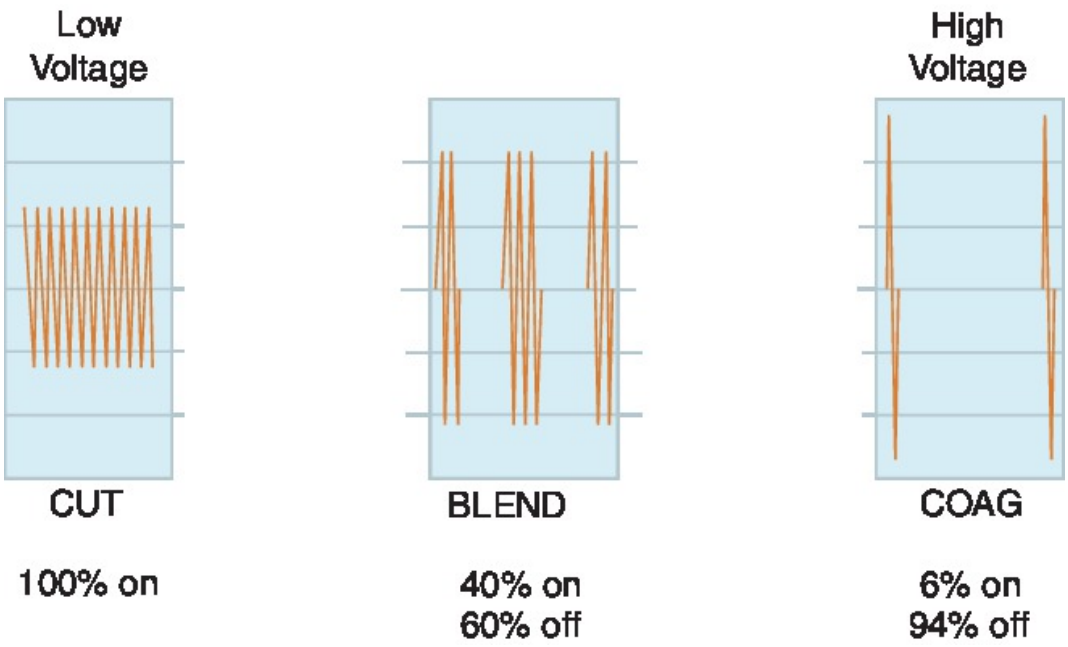


**FIGURE 7.7** Continuous (CUT) vs interrupted (COAG) duty cycles differ in the duration that RF energy is delivered over time and by the voltage required to deliver that energy. Most generators offer a BLEND mode that offers some features of both extremes by varying the duration of the duty cycle.

All bipolar devices deliver RF energy using a continuous sinusoidal waveform (CUT). Modern instruments available to use in the bipolar mode also employ use of compressive force to reduce vascular pulse pressure and subsequently blood flow through the intervening tissue and ensure fusion of the vessel walls (coaptation). This further helps the energy to remain concentrated between the electrodes to achieve maximal desired tissue effect. Additionally, there is often the incorporation of feedback mechanisms to determine when the intervening tissue is sufficiently desiccated. This tissue response technology allows an adaptive electrosurgical unit to measure tissue

impedance thousands of times and modulate energy delivery as the tissue effect is achieved.

Although the terms CUT and COAG have become ingrained in our electrosurgical lexicon, it is more useful to think of waveform and technique with respect to the tissue effect achieved. RF energy may be used to cut through tissue via rapid increase in temperature in a noncontact mode (vaporize) or coagulate tissue through slow deep dehydration and denaturation of proteins (desiccate) or by the arcing of a superficial spray of electrons (fulgurate), often resulting in tissue carbonization (**TABLE 7.1**). Temperature changes have been identified with each of these effects. While cell death is a function of time, temperature, and pressure, we know that irreversible damage in tissue generally occurs at ≥60 °C by intracellular protein denaturation and coagulation. Cellular dehydration (slow evaporation of water) occurs when tissue is heated to ≥60 °C, which is referred to as *desiccation*. Rapid temperature rises to ≥100 °C will cause cell walls to rupture as liquid water changes to steam by a process known as *vaporization*.

### TABLE 7.1
### Tissue Effect Can Be Altered by Altering the Waveform and Using the Active Electrode With a Contact or Noncontact Technique

| | NO CONTACT | CONTACT |
|---|---|---|
| **CUT (continuous)** | Vaporization | Desiccation |
| **COAG (interrupted)** | Fulguration | Desiccation |

## Tissue Effects

### *The Effects of Waveform and Tissue Contact*

As mentioned earlier, the CUT mode delivers a continuous sinusoidal waveform alternating in direction at the high frequency determined by the electrosurgical unit. If this RF is delivered through a small active electrode (high current density) and using a noncontact technique, rapid and intense intracellular heat is generated, vaporizing the affected cells. The steam vapor occupies a space much greater than the water of the cell, creating two effects. First, it literally explodes the cells. Second, and equally important, it dissipates the heat generated to reduce thermal damage to adjacent tissue. Consequently, there is little or no coagulation effect. If the active electrode is moved too slowly, or allowed to dwell in one spot too long, the tissue becomes dehydrated, impedance is increased, and tissue is more slowly dehydrated (desiccated). Therefore, for efficient and effective separation of tissue, the surgeon should use a continuous waveform (CUT) with a small or thin active electrode that is activated just prior to tissue contact. With a peak voltage of about 200 V, the ionized air facilitates a layer of steam as the electrode glides by exploding cells with minimal surrounding heat or tissue coagulation.

In the COAG mode with a frequency of 500 kHz, bursts of RF energy occur over 31 000 times per second. However, this accounts for <5% of the time in pure COAG mode. It is during the “off” intervals that the tissue is cooled and denatured (coagulated), which increases impedance. If the COAG waveform had the same peak voltage as the CUT waveform, the average power delivered per unit time would be less because the RF energy is off the majority of the time. To deliver the same power, the COAG waveform must deliver the same average voltage as the CUT waveform. To do so, there must be large peak voltages during the percentage of time that the RF energy is being delivered (**FIG. 7.8**). The high-voltage sparks created are more widely dispersed, and due to the intermittent heating effect, cellular temperature does not increase rapidly or sufficiently to vaporize. Consequently, cells are more slowly dehydrated and do not explode to create an incision in tissue, resulting in greater tissue impedance. Because of the higher peak voltage (greater electromotive force), COAG waveforms can drive current through higher impedance, which permit a potentially wider

yet more superficial tissue effect when the electrode is not in contact with the tissue (known as fulguration). In contrast, desiccation results when the electrode is directly in contact with the tissue. This creates deep penetration of heat and minimal charring of the tissue surface. Fulguration and desiccation are both forms of tissue coagulation. Given equal current density, noncontact fulguration is more efficient at creating surface necrosis and charring.

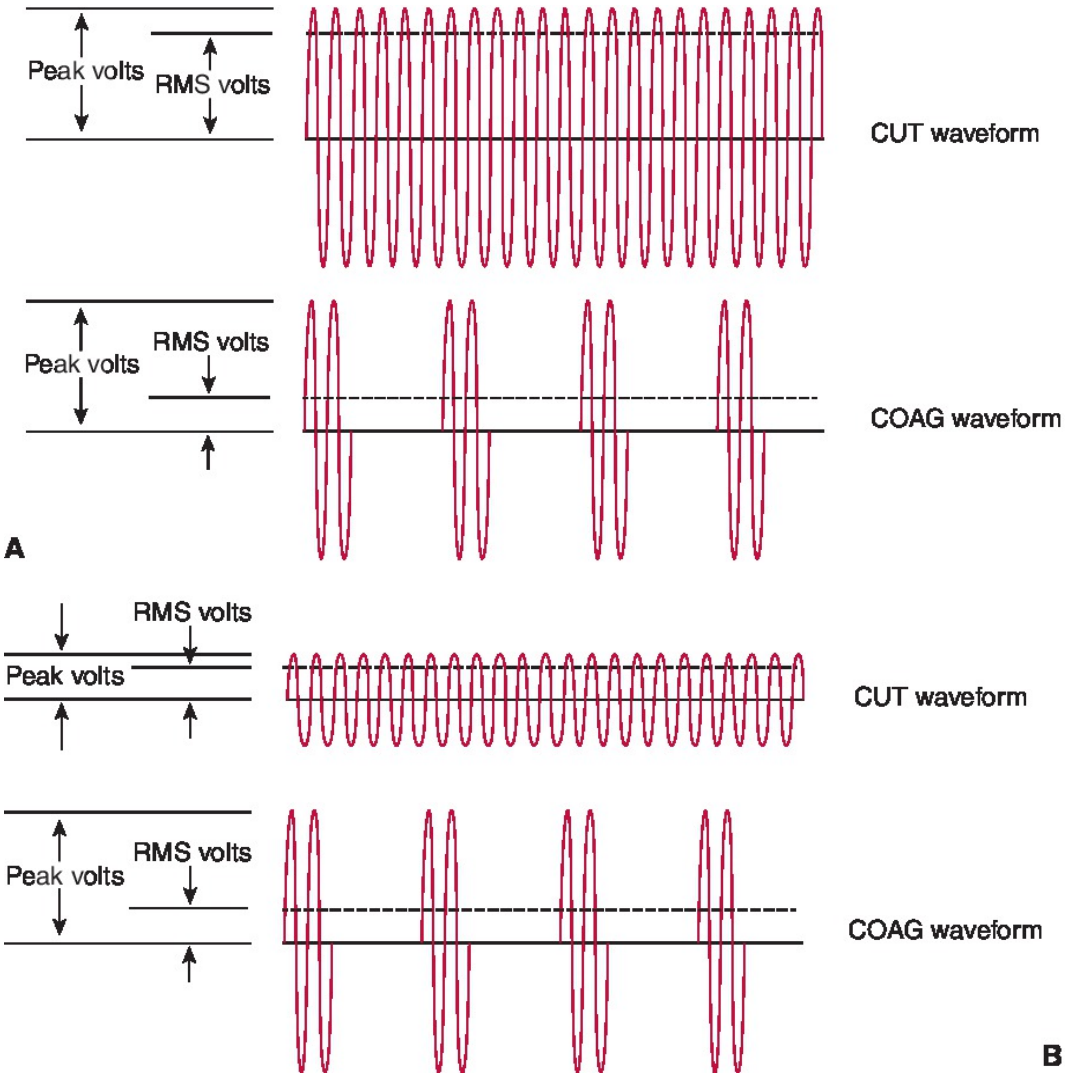


**FIGURE 7.8** When the *peak voltage* is the same between pure CUT and pure COAG current (as depicted in **panel A**), the amount

of power delivered in COAG is only one-third that of CUT. Conversely, when the *peak power* is the same between pure CUT and pure COAG current (as depicted in **panel B**), the peak voltage of COAG is about three times greater than that of CUT. RMS, root mean square.

The speed with which the active electrode is moved can also contribute significantly to tissue effect. At an ideal speed, the active electrode glides through a path of vaporizing cells to cut tissue with minimal collateral effects. On the other hand, moving the electrode too slowly (increased dwell time) will generate increased heat in surrounding tissues resulting in a proportional degree of tissue coagulation. Once the superficial tissue is fulgurated, it acts as its own insulator. Dwelling over the same tissue longer than what is required for the fulguration effect has potential to cause deeper tissue injury with potential for stray paths of electron flow. Similarly, moving the active electrode too fast will result in a continuous waveform contact mode (desiccation) as it overshoots the microenvironment of ionized air that creates a layer of steam from vaporized cells.

## *Electrode Shape*

The surgeon can use a combination of waveforms, active electrode characteristics, and surgical technique to achieve tissue effects (**FIG. 7.9**). Additional manipulation of tissue effects may be accomplished by altering the size of the electrode. Electrode size controls current density. A needle tip electrode will yield greater current density than the broad surface of an electrosurgical bladed electrode. Therefore, the needle tip electrode will produce quicker higher temperatures favoring vaporization (cutting), whereas the broad blade will result in

a lower current density and slower and lower rise in temperature, favoring tissue desiccation.

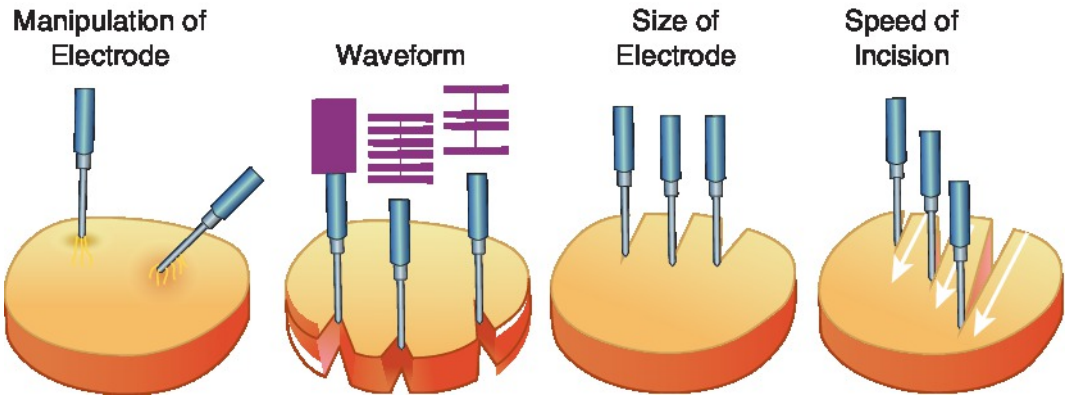


**FIGURE 7.9** Variables that moderate tissue effects include electrode manipulation (contact vs noncontact), waveform (CUT vs COAG or BLEND), size of electrode (current density), and speed of active electrode movement.

## *Tissue Impedance*

Finally, to achieve a desired tissue effect, the surgeon must take into consideration the constitution of the target tissue. Tissue impedance, which primarily depends on water content, will also affect the electrosurgical outcome. Impedance is high in desiccated and scarred tissues, moderate in adipose tissues, and very low in vascular tissues with higher water content. The impedance of tissue is dynamic during electrosurgery. Moreover, the power needed to accomplish a particular electrosurgical effect may vary from one patient to another. Lean, muscular patients commonly require lower power settings to achieve the desired tissue effect. Obese or emaciated patients may provide more tissue impedance to the electrical current and so may require more applied power to achieve

the same effect. Power requirements to achieve a given electrosurgical effect will be higher whenever an electrode is applied to an area of higher impedance. With higher impedance, there is increased possibility of stray current seeking alternative sites of action. For example, as water evaporates and tissue coagulates, impedance rises—at times to the point that current is inhibited from flowing through the tissue.

### *Location of the Dispersive Electrode*

Dispersive electrode placement is also a factor. The farther away from the surgical site, the higher the power required for surgical effect. If the surgeon reflexively increases the power setting and consequently the output voltage, the current is more likely to overcome the tissue impedance and seek an alternative pathway of least resistance to the ground, which may lead to unintended thermal injury.

## SAFETY CONCERNS WITH MONOPOLAR CIRCUITS

As we have seen, the principles of Ohm law along with the rules "electricity must complete a circuit or it will not flow," "electricity goes to ground," and "electricity follows the path of least resistance" provide the basis of predictable use of RF energy in surgical applications. However, these same principles illustrate the potential dangers of unintended energy paths. Complications arise when electrosurgical principles are not understood, and devices are not set or used properly (**VIDEO 7.1**). Injuries from electrosurgical devices have been reported anywhere from 2.2 to 5/1000. Of note, these injuries are not always recognized at the time of surgery; electrosurgical injuries frequently present complications between 3 and 10 days postoperatively. It is believed that there are a larger number of unrecognized injuries, some of which do not become substantial and are thus underreported. Unintended thermal injury to tissue can be related to many factors, including direct and indirect

application of energy. We discuss here examples of the most common sources of unintended energy application, potentially leading to patient injury.

## Open Activation

Deliberately activating the active electrode prior to contact with tissue (open activation), the surgeon can create a vaporization or fulguration effect (discussed earlier). Perhaps a good example of the latter is the use of a ball electrode to fulgurate the bed of a cervical loop electrosurgical excision procedure (LEEP). Unfortunately, if the active electrode is activated excessively far from the target tissue, the energy charge builds up at the tip of the electrode as it encounters the very high impedance of air. With sufficient power, the electromotive force (voltage) can cause the RF energy to discharge the energy across the impedance of the insulator to the nearest site, potentially creating stray circuits and unintended tissue injury. Also, if metal is present in the field, energy can arc to that as the path of least resistance.

## Direct Coupling

Direct coupling occurs when an active electrode comes into contact with a conductive instrument that channels RF energy to another site (tissue) with which it is in contact. An intentional use of this principle would be passing current from an active electrode through a pair of forceps or hemostat that is grasping a vessel at the operative site. Applying the tip of the handpiece close to the tissue and activating after making contact, avoiding an open activation, delivers a more thorough desiccation. Also, the person holding the hemostat or forceps should use as much of their hand as possible to avoid current concentration and resulting burn to themselves when they become the path of least resistance as the tissue gets desiccated. A common example of untended direct coupling in laparoscopy occurs when activated monopolar scissors touch adjacent bowel graspers, causing direct transfer of RF energy to the unintended site (bowel).

## Insulation Failure

This type of “stray energy” perhaps occurs more frequently in laparoscopy than in laparotomy. It is frequently unrecognized, since <15% of the operative field is typically seen when using a video camera and laparoscope. Laparoscopic instruments are covered by an insulator to protect surrounding tissue. A break in the insulation covering the shaft can occur through a variety of mechanisms such as moving the instrument repeatedly through a trocar or when cleaning and processing for reuse, potentially resulting in RF energy discharging through these breaks with effects like that described in open activation. The bowel is a frequently affected target of stray RF energy from insulation failure. Usually, blanching of sigmoid wall (or other tissue) occurs, and the surgeon should assume that tissue destruction is deeper than is visible. This type of tissue injury (pale, blanching) has a higher likelihood of breaking down in the near future. An unrecognized bowel injury has a 3% mortality.

## Capacitive Coupling

Capacitance refers to the ability of an object to store an electrical charge. Capacitance coupling may occur when two conductors in proximity to one another are separated by an insulator. It is best described as a mechanism whereby electrical current in the active electrode induces a current in another nearby conductor (unintended) separated by an insulator. For example, when using an operative laparoscope, the insulated active electrode (eg, scissors) is passed through a channel within the operative scope. This produces the ideal situation for capacitive coupling of the laparoscope by the active electrode (**FIG. 7.10**).

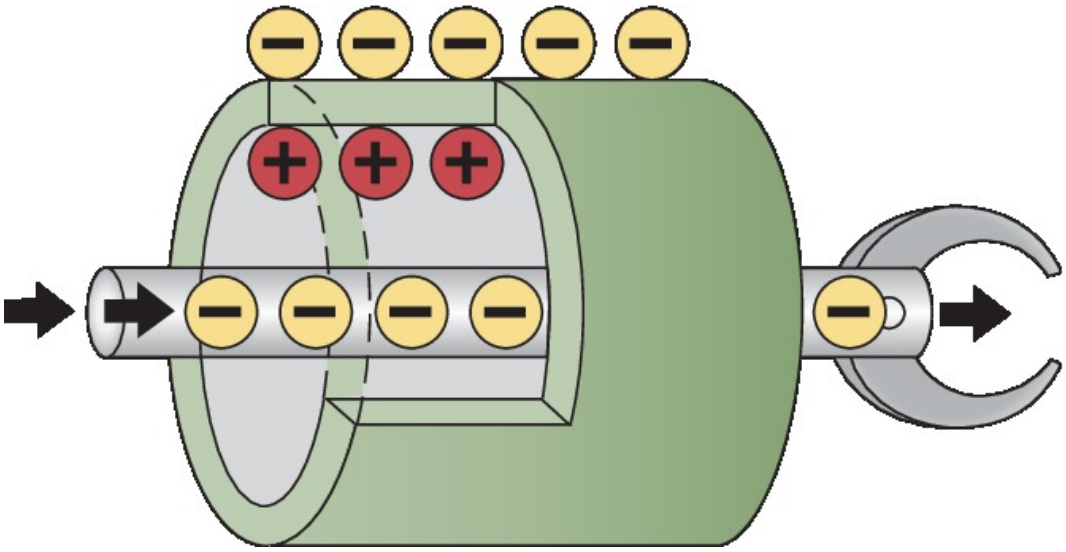

**FIGURE 7.10** Capacitance coupling is the induction of electrical current between two conductors separated by an insulator. The active electrode carries active current and induces a separate current in the nearby conductor.

Some degree of capacitive coupling occurs with all standard monopolar electrosurgical instruments, but it is rarely a hazard. Whether the “stray energy” of capacitive coupling causes clinical injury depends on (1) the total amount of current transferred, (2) the ability to prevent arcing discharge of the built-up energy to an unintended tissue target, and (3) concentration of the current (ie, the current density) as it makes its way back to the dispersive electrode. Alterations in either voltage or frequency can produce capacitive coupling. The low-voltage CUT mode exhibits less capacitive coupling than COAG does. Thin insulation decreases the effective separation of the electrode from the surrounding conductor and will increase the amount of induced current.

Common conditions exist where capacitive coupling can cause sufficient current to cause an injury. When a metal trocar is used, it can be capacitively coupled to the active electrode. Additionally,

when a conventionally insulated electrode is passed through a metal suction-irrigator, ~70% of the current may be induced in the suction-irrigator. The same situation can occur when an active electrode is passed through the operating channel of a laparoscope. An all-metal cannula through the abdominal wall will disperse stray current through the abdominal wall as the RF energy is discharged over a larger surface area on its way to the dispersive electrode with minimal or no effect. However, if the metal trocar is anchored by a plastic sleeve in the first example, or if a plastic trocar is used, then RF energy can build up until it overcomes the impedance of surrounding air to discharge through the path of least resistance to an unintended tissue target. Another common and rarely recognized example occurs when the wire of a monopolar electrosurgical instrument is wrapped around a hemostat attached to a surgical drape for stabilization (**FIG. 7.11**). With prolonged use of the electrosurgical instrument, the hemostat may become charged through capacitive coupling and that electrical energy may discharge seeking ground through the path of least resistance causing a drape fire or a burn to the patient.

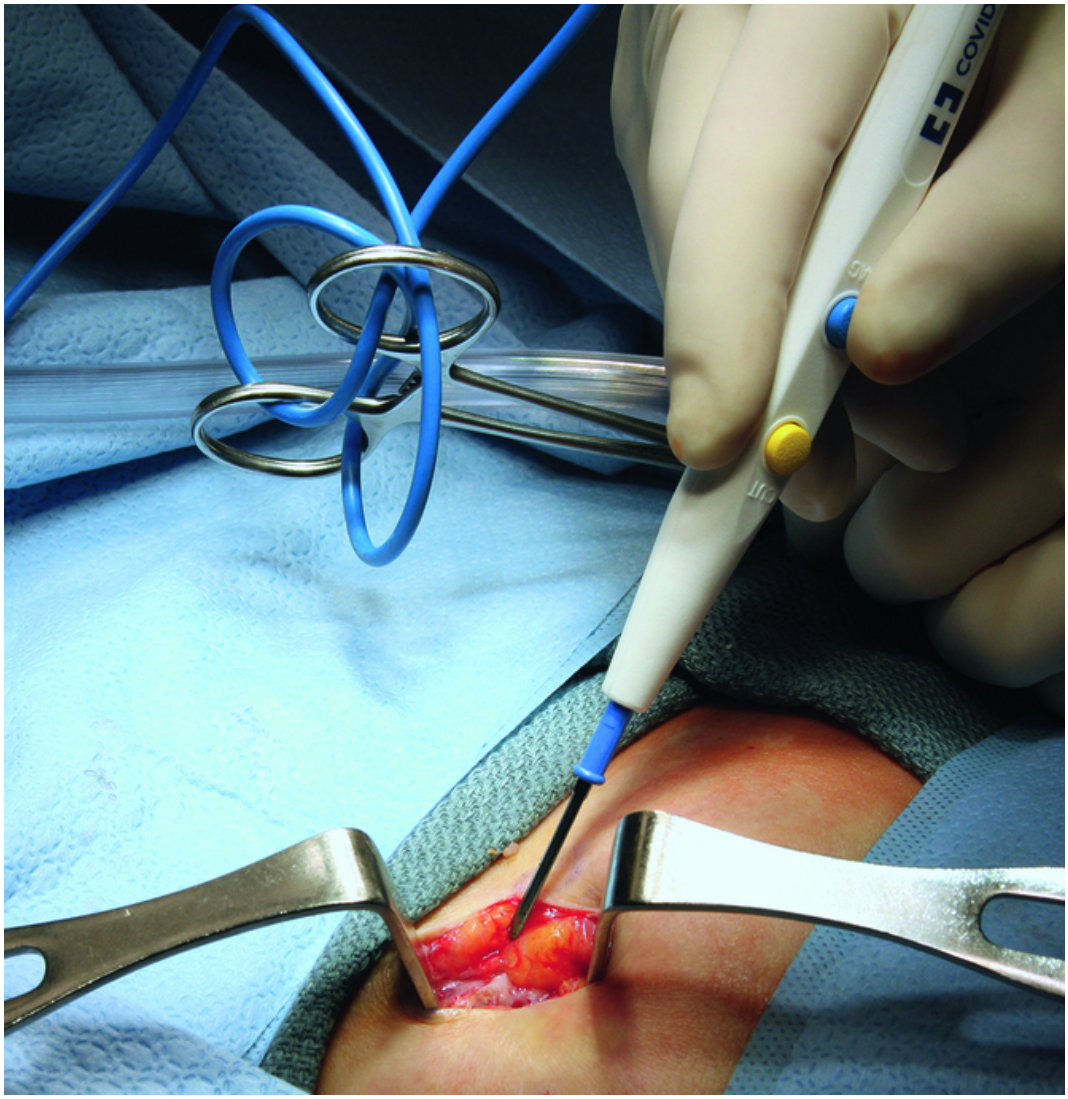

**FIGURE 7.11** Illustration of a common error. Securing the wire of an electrosurgical instrument to the drape with a hemostat provides an opportunity for capacitive coupling and discharge of built-up energy to create a drape fire or a patient burn. This is a safety concern and should be avoided.

## Active Electrode Monitoring

The potential for injury from capacitive coupled currents during monopolar electrosurgery can be reduced with an understanding of the biophysics but can be eliminated by active electrode monitoring systems that “collect” stray current and confine capacitive coupling to the surgical instrument. Such a device is commercially available that eliminates the risk of capacitance regardless of the type of trocar sleeve used (Encision, Inc., Boulder, CO). This device consists of a shroud over the active electrode shaft that shunts all capacitance-coupled current back through a return electrode to the electrosurgical unit, which avoids unintentional RF energy discharge. Additionally, if there is any breech in the insulation of the active electrode that could promote direct coupling to other metal instruments or adjacent tissue, the surgeon is alerted with an audible alarm (**FIG. 7.12**).

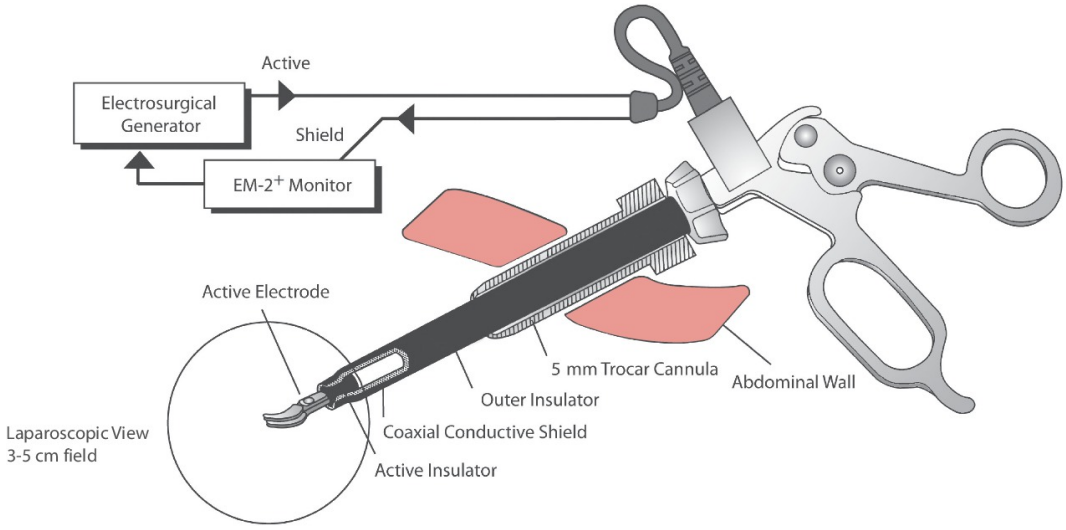


**FIGURE 7.12** The Encision (formerly ElectroShield) system eliminates the threat of unintentional capacitance injury when using monopolar instruments during laparoscopy by returning capacitance-induced current back to the generator. If an insulation breakdown occurs, the surgeon is alerted.

# ARGON BEAM COAGULATOR

The argon beam coagulator is a monopolar active electrode housed inside an insulated cannula through which argon gas is dispelled at up to 12 L/min (laparotomy) or 4 L/min (laparoscopy). It is not, as is commonly believed, a type of laser. This instrument is ideal for controlled noncontact superficial fulguration of tissue, owing to two unique properties of argon gas. First, electrons prefer to follow a stream of argon gas rather than pass through room air or carbon dioxide ($CO_2$), as each of the latter has a higher resistance to electron flow. Accordingly, because electrons choose to flow the path of least resistance, they stay collimated (parallel alignment) in the flow of argon, so sparks can be directed with efficiency. Second, the ionization properties of argon gas flowing over the active electrode enhance the distance the spark can travel to complete the circuit to the tissue surface. These properties create a bright bluish hue to the sparks, which makes the beam easy to see and aim appropriately. This instrument is best used for coagulation on the tissue surface (**FIG. 7.13**). The gas, expelled under pressure, blows the pooled blood away from the surface bleeders, making coagulation more discrete and efficient. To create the planned fulguration effect, the wand must move like a paintbrush to prevent deep tissue damage.

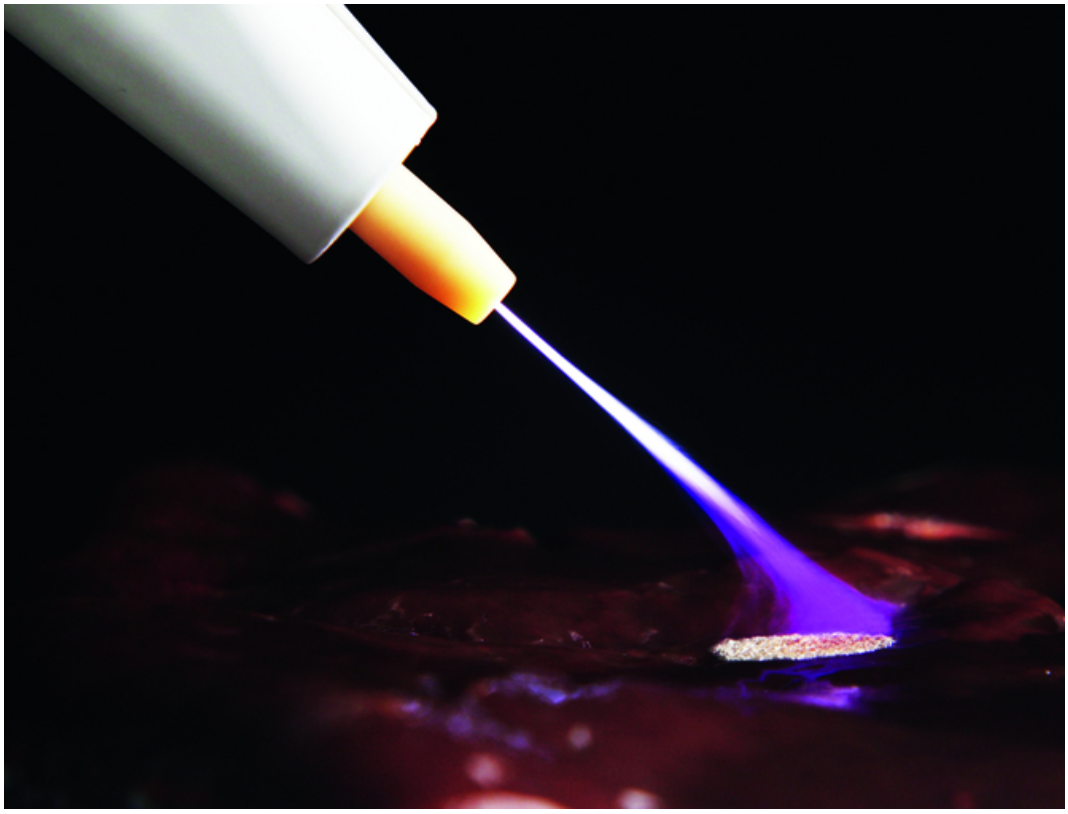

**FIGURE 7.13** Argon beam coagulator. Electrons travel in a collimated fashion along the path of argon gas, which extends and directs the spark to the tissue surface. The ionized gas has its own unique hue that makes the sparks easily visible for accurate fulguration.

# BIPOLAR INSTRUMENTS

## First Generation

Bipolar electrosurgical instruments became popular in the mid-1970s as an alternative to monopolar instruments with hopes of avoiding complications of stray current as described above. Although bipolar

electrosurgical instruments are considered generally safer than monopolar instruments with respect to stray RF injury, they are not without complications. It is important to remember that the zone of thermal damage extends beyond that of the electrodes at the instrument tip and sides. Once the tissue is sufficiently desiccated, further application of electricity can potentially propagate heated water and subsequent steam to adjacent tissue, causing a thermal spreading effect. To reduce this potential, the surgeon should cease desiccation once vapor is no longer visualized and when the tissue becomes white in color.

Excessive desiccation can cause stickiness of the tissue as a result of carbonization, often referred to as an “amalgam.” Additionally, the active electrode can become adherent to the tissue, due to molecular breakdown of the cellular contents into sugars if the COAG function is used for a prolonged period of time. When deep tissue desiccation is required, the CUT function should be used to ensure deep penetration of tissue. If the COAG function is used instead, in tubal sterilization, for example, it can cause immediate surface char and cessation of the flow of electrons while increasing tissue impedance, increasing lateral thermal spread, and preserving patency of the underlying tubal lumen. Use of the CUT mode allows a more precise and controlled spread of energy within the tissue due to its continuous, low-voltage waveform.

When using bipolar instruments, the use of an “in-line ammeter” is recommended to help monitor the increase in tissue impedance indicating complete tissue desiccation.

## Second Generation

After the introduction of simple bipolar electrosurgical devices, more versatile instruments were developed, combining tissue desiccation and vaporization in the same instrument. Combining these functions within one instrument improves efficiency, because the surgeon need not change out surgical instruments for various tissue effects. There was a simultaneous desire to reduce the thermal spread, tissue carbonization, and “plume” formation of conventional bipolar instruments. Several bipolar instruments known as “sealing” devices

are now available that can be used to grasp, dissect, and seal vessels up to 7 mm in diameter and transect tissue. These tissue-sealing devices all employ the components of pressure, temperature, and time using tissue response technology to bring opposing edges together. They denature and mobilize collagen and other proteins within the tissue at elevated temperatures to fix or reorganize the collagen fibers into a tissue seal. Then, some mechanism is used to transect the sealed tissue.

## *Plasma Kinetic Technology*

The Plasma Kinetic platform (Olympus America, Center Valley, PA) delivers pulsed RF energy through a bipolar handpiece, with continuous tissue impedance monitoring. This device is designed to deliver less heat overall while insuring adequate temperature for effective collagen denaturation without rapid desiccation. As the generator delivers a pulse of RF energy, tissue impedance is measured and voltage is altered (decreased) to match the impedance. In between pulses, the tissue cools, allowing for renaturation (fixing) of the collagen. This cycle continues until complete tissue sealing and desiccation have been accomplished. Some plasma kinetic devices include a knife blade that can be advanced for cutting. Several related devices are available using this energy platform for applications in laparotomy, laparoscopy, and vaginal procedures. There is at least one plasma kinetic device that also incorporates ultrasonic technology for simultaneous sealing and cutting of tissue.

## *LigaSure Technology*

The LigaSure device (Medtronic, Boulder, CO) is a bipolar device that combines both high pressure and pulsed energy. The tissue to be sealed is grasped in the jaws of the instrument, and a calibrated force is applied to the tissue during energy delivery. Tissue impedance is monitored while delivering the appropriate amount of continuous RF energy required to seal the tissue. During the process, elastin and collagen are denatured, creating a permanent

seal that resists deformation and can withstand >360 mm Hg. A cutting blade is then deployed to cut the sealed tissue. Instruments for use with laparoscopy, laparotomy, and vaginal surgery are available with this technology. There is no benefit to activating the device more than once for any given seal. Paradoxically, a second activation too close to the initial seal may be impacted by steam that can strain and weaken it.

## *EnSeal Technology*

The EnSeal Laparoscopic Vessel Fusion System (Ethicon Endo-Surgery, Cincinnati, OH) is a bipolar sealing device. The temperature of the tissue pedicle is determined by the local conductivity of the high-compression jaws of the device. A carbon crystalline matrix limits tissue temperature along the seal line by creating a conductive polymer chain at temperatures <100 °C that dissociates at temperatures >100 °C, thereby limiting energy delivery and lateral thermal spread. The device has a central mechanical blade that simultaneously compresses the tissue to force water out of the cells, which reduces excess steam within the tissue and serves as the cutting function.

## *VIO Technology*

VIO Technology from Erbe (Marietta, GA) is designed to deliver the lowest effective adjusted power output in both CUT and COAG modes. The device automatically detects the formation of microelectric arcs (sparks) and is designed to afford cutting results largely independent of the cutting speed, shape of electrode, and tissue type. It is also designed to provide reproducible coagulation with optimally adjusted power output. In addition to standard monopolar and bipolar applications, this technology includes the option for an ultra–low-voltage monopolar waveform, which seals and fuses vessels up to 7 mm via a proprietary voltage control and power dosing output. For monopolar applications, this technology is equipped with a Neutral Electrode Safety System (NESSY) that

monitors not only the electrical connection between the unit and the electrode but also the dispersion of high-frequency current.

# ELECTROSURGICAL APPLICATIONS IN OPERATIVE HYSTEROSCOPY

## Monopolar

The same electrosurgical principles that have been discussed previously in this chapter apply to hysteroscopy as well, with one notable exception, that is, the need to create distension of the uterine cavity and provide an electrically insulated environment (replacing the insulation of air during laparotomy or $CO_2$ gas during laparoscopy). For monopolar resection, this is accomplished through the use of nonionic fluids such as glycine, mannitol, or sorbitol. These media are absorbed to varying degrees, depending on factors such as operative time, intracavitary pressure, and vascular nature of the resected tissue. With excessive absorption come the hazards of fluid and electrolyte imbalances and complications from metabolism of the medium itself (eg, glycine is metabolized to water and ammonia). These issues are reviewed in Chapter 15: Hysteroscopy.

Hysteroscopic techniques may include endometrial loop resection and ball ablation. Variability in technique also includes watts used, speed of the electrode, and even pressure applied to the uterine lining (more pressure results in greater active electrode contact and decreased current density). Some surgeons use only COAG waveform, while others use CUT or even some sequential or spatial combination of the two. However, we do know that by using the CUT waveform, there is less bubble generation and accumulation on the anterior surface of the cavity. At the end of the ablation procedure, some surgeons switch to a COAG waveform at 75 W. With the increased peak voltage of this waveform, electrons driven by higher electromotive force “seek out” undertreated areas of lower impedance, ensuring complete tissue coagulation.

There are three common, if not unique, electrosurgical complications associated with operative hysteroscopy, aside from the fluid management issue described briefly above. The first is due to uterine perforation by an active electrode during RF energy application. This can be minimized by (1) never advancing the hysteroscope with the electrode extended and (2) only energizing the active electrode while retracting the electrode toward the hysteroscope. If this type of complications does occur, then laparoscopy or laparotomy (depending on skill level) may need to be undertaken to evaluate possible pelvic or abdominal organ injury. The second is accidental burns to the vagina or perineum through capacitive coupling of the outer sheath of the resectoscopic hysteroscope. Because the inner and outer sheaths of the resectoscope (conductors) are separated from the active electrode by nonionic fluid (insulator), capacitive coupling can occur. Relatively high current density in the outer sheath touching small areas of genital tissue can create a burn injury. Finally, injuries can also occur from defects in electrode insulation, especially when interrupted COAG current is used and the cervix is overdilated and is in contact with <2 cm of the outer sheath. The high current density created by prolonged activation along already desiccated tissue (increased impedance) and subsequent current diversion is responsible for this type of injury.

# Bipolar

A family of instrumentation is available for hysteroscopy that uses bipolar technology to attain the desired electrosurgical effect. An advantage of bipolar electrosurgery includes the ability to use in a saline environment, mitigating the potential hazards of nonionic fluid absorption. Additionally, isolation of the electrical circuit occurs between a set of closely separated electrodes separated by a ceramic insulator. Performance is similar to its monopolar counterpoint, providing for tissue vaporization and desiccation while retaining all of the inherent safety features of bipolar electrosurgery. However, gas generation is likely higher (due to the requisite higher power settings), giving rise to concerns for gas embolism.

Bipolar hysteroscopic resection devices are made by a variety of surgical instrument companies (Karl Storz Endoscopy America, El Segundo, CA; Richard Wolf Medical Instruments, Vernon Hills, IL; Olympus America, Center Valley, PA; and Ethicon Women's Health and Urology, Somerville, NJ) and come in a variety of outer diameters from 7 to 9 mm. They all consist of a dedicated bipolar electrosurgical generator and a variety of specialized hysteroscopic bipolar electrodes for different tissue effects. A key feature of the system is its ability to adjust automatically to an optimal power setting depending on the type of electrode. The generator varies the output power in response to local impedance changes at the active electrode. A high-impedance vapor pocket is created that surrounds and insulates the active electrode from completing the circuit through the normal saline until tissue contact is made. Once contact occurs, current flows through the tissue and, by seeking the path of least resistance, returns through the saline to the proximal return electrode, located close to the active electrode, and finally back to the generator.

There are two nonresectoscopic endometrial ablation devices currently approved by the FDA that employ bipolar current: NovaSure Global Endometrial Ablation System (Hologic, Marlborough, MA) and the Minerva ES Endometrial Ablation System (Minerva Surgical, Santa Clara, CA). While both devices are bipolar current driven, there are some important differences in the energy delivery.

NovaSure includes a single-use, three-dimensional bipolar device and adaptive RF generator. The handheld device deploys a fan-shaped bipolar electrode that conforms to the uterine cavity and the power output to ensure ablation of the uterine cavity is calculated. Using a constant power output generator, the maximum power delivered is 180 W. The depth of ablation is controlled by monitoring tissue impedance during the procedure. A shorter center-to-center distance between electrodes provides a shallower depth of desiccation at the areas and lower uterine segment. A wider center-to-center distance between electrodes provides for a deeper ablation in the uterine corpus. The endometrium does not require pretreatment or thinning prior to treatment. RF energy delivery

continues until monitored tissue impedance reaches 50 ohms (representing a distinction between the lower resistance of the endometrium and the higher resistance of the myometrium) or after 2 minutes, at which time the NovaSure System discontinues energy delivery.

The Minerva device also includes a fan-shaped single-use device with an adaptive RF generator. However, there are some important differences in the mechanism of energy delivery between these two systems. The Minerva device is covered with a silicone membrane creating a chamber that contains argon gas and an electrode array. The argon gas is ionized using bipolar RF to create a plasma. This allows for three distinct and simultaneous energy transfer mechanisms to accomplish tissue ablation: (1) delivery of bipolar current directly into the tissue, (2) direct heat transfer between the silicone membrane heated by the generated plasma and the endometrial tissue in contact with it, and (3) heating of all fluids within the endometrium and uterine cavity, which is especially beneficial in ablating tissue not in direct contact with the silicone membrane. The RF generator initially delivers 40 W of RF energy but continuously monitors the ablation process and dynamically reduces power over the course of the 120-second ablation cycle, limiting energy delivery only to areas that still require ablation.

# ULTRASONIC TECHNOLOGY

Ultrasonic devices generate tissue effects similar to advanced bipolar devices but do not employ electrosurgical principles. The source of thermal energy is vibration of the ultrasonic jaws that heat the tissue by mechanical/frictional energy. The energy oscillating between the jaws through the tissue excites the water molecules generating heat that is absorbed by the jaws acting as a heat sink. Mechanical energy is typically generated at frequencies between 23 and 55 kHz.

Different tissue effects can be achieved by varying the displacement of the active jaw. The higher displacement setting (100 μ) is better for rapid tissue transection while minimizing lateral thermal spread, but the effectiveness in coagulation of tissue and

vessels is decreased. Alternatively, a shorter oscillation (50 μ) is superior for tissue hemostasis, yet results in greater potential for lateral thermal spread and cavitation.

Cavitation occurs when steam released from vaporized cells expands tissue planes. Although this does occur to some extent with monopolar vaporization, it occurs at lower temperatures with ultrasonic energy due to the oscillating tip. Thus, ultrasonic devices are similar to advanced bipolar devices in that they both sequentially convert electrical energy to mechanical energy to thermal energy to facilitate tissue effects. However, with bipolar devices, the source of friction is intracellular (molecular), whereas ultrasonic devices create extracellular friction from the oscillating shaft followed by intracellular heating without the passage of electrical current through the tissue. It is important to remember that harmonic devices tend to stay hot for several seconds after completion of the seal, potentially resulting in an unintended injury if the tip touches nearby viscera.

There are multiple ultrasonic devices currently available, including the Harmonic scalpel, Harmonic ACE+7, and HD1000i (Ethicon Endo-Surgery, Cincinnati, OH), AutoSonix and Sonicision (Medtronic, Boulder, CO), and SonoSurg (Olympus America, Center Valley, PA). Most harmonic devices are now approved for sealing 7-mm vessels, similar to the bipolar devices described.

# LASER TECHNOLOGY

## Historical Perspective and Background

Although the basis of laser technology was first described by Albert Einstein in 1917, working lasers did not appear until 1960 and were not applied to medicine until about 5 years later. LASER is an acronym for “light amplification by stimulated emission of radiation.” Energy from lasers is derived by the ability to generate light emissions that are both highly collimated (parallel rays) and coherent (in phase, noninterfering wavelengths) and that can be delivered to the surgical site by a series of mirrors or fibers without high

degradation of these properties. In doing so, virtually any surgical procedure requiring vaporization, ablation, incision, excision, or coagulation of tissue can be performed using lasers. Laser energy can destroy tissue layer by layer, without touching it, with minimal thermal damage.

Lasers generate light energy through the release of photons from excited atoms in a medium contained within an optically resonant chamber. The nature of the active lasing medium, a collection of atoms usually in the form of crystals or gas, is how the type of laser derives its name. When the medium is stimulated by an external source (eg, electricity), the atoms circulating the nucleus of the medium are stimulated into a higher-energy orbit. As the electrons decay to resting levels, light energy in the form of a photon is released. This process is known as spontaneous emission. Not only can electrons be stimulated by an external energy source, but also they can be bombarded by neighboring photons, which causes decay and emission of a photon that is identical in phase (coherent) and in wavelength (monochromatic) and travels in the same direction without divergence (collimated). This process is called stimulated emission.

The optical cavity in which the electrons reside, and where the photons are produced, is lined by two mirrors. One of the mirrors is completely reflective, and the other is a semitransparent mirror at one end of the linear axis of the optical cavity. The direction in which photons are emitted is totally random. They are focused by the mirrors so that most resonate back and forth along the axis of the optical chamber. Photons that are aligned with the optical axis of the chamber are released when the laser is “fired,” emerge through the semitransparent mirror, and are emitted from the laser as the monochromatic parallel coherent laser beam.

Laser generators have focusing attachments for delivery of the light energy for superficial use (eg, colposcopy or lower genital tract), for intravaginal fractional reconstruction, for laparotomy, and for laparoscopy. Historically, all lasers have been able to transmit energy via a flexible quartz fiber. The exception is the $CO_2$ laser, which was transmitted along rigid tubes reflected by mirrors. However, a hollow-core flexible fiber delivery system recently has been developed for

delivery of $CO_2$ laser energy (OmniGuide, Cambridge, MA, and Lumenis, Yokneam, Israel) with adapters for external, laparoscopy, and robotic use.

# Principles of Laser Technology

Three parameters impact the amount of laser energy delivered. The first variable is wattage. Power is dependent on hand speed and surgical technique. As a physician gains experience in use of their laser platform, they often increase power to treat more tissue in less time. Unlike electrosurgery, higher power results in less thermal damage, but if dwell time is too high, the energy will penetrate more deeply than intended. This is why at higher power, hand speed is faster to accommodate the tissue effect.

The second parameter is time. Simply put, the longer the laser remains focused on one spot, the more energy is applied to that area. This can be modified either by moving the laser beam around within the desired treatment area or by delivering the laser energy in pulses. Since the thermal relaxation time of soft tissue is ~0.8 ms, pulsed lasers that have an on time at or below this parameter minimize conduction of heat.

The third parameter that can be controlled is the spot size of the beam. This is analogous to altering the current density of RF energy at the tip of the active electrode to alter tissue effects. Power density, expressed in $W/cm^2$, is inversely proportional to the area of the spot size, such that doubling the beam diameter reduces power density to one-fourth. Conversely, decreasing spot size in half results in a fourfold increase in power density.

As previously mentioned, laser energy emerges from the generator in a coherent and parallel fashion, which could hypothetically travel in this form to infinity. However, the laser light is focused to a fixed focal length, depending on the application of the device (external, laparotomy, or laparoscopy use). The surgeon can further alter the focus with additional lenses or mechanical devices. By focusing or defocusing the laser energy, it is used as a cutting or coagulating tool.

# Types and Applications of Lasers

The first gynecologic application of laser technology was reported in 1973 when Kaplan and colleagues used $CO_2$ laser to treat cervical lesions. Potassium titanyl phosphate (KTP) and neodymium:YAG (Nd:YAG) lasers became increasingly popular for laparoscopic applications, especially related to treatment of endometriosis and infertility patients, partially because of their specific properties but equally because a flexible fiber delivery system was comparatively easier to use than the rigid mirrored system of the $CO_2$ laser. However, because of increasing cost consciousness and availability of superior advanced radiofrequency-based devices in the late 1990s, laser technology for all but external lower genital tract disease dramatically decreased.

There are three zones of laser tissue damage: (1) the area vaporized, (2) the area of tissue death that results from the heated tissue short of vaporization, and (3) the area of tissue damage caused by conduction of the heat away from the lased site. Because it removes tissue with vaporization and evacuation, the suctioned plume allows the tissue base to heal without a devitalized tissue covering. Postoperative pain is reduced because nerve endings are sealed by the beam.

In gynecologic surgery, the most commonly used lasers are $CO_2$, argon, KTP, and Nd:YAG (**TABLE 7.2**). The argon and KTP lasers produce light waves of a specific wavelength, giving a characteristic color. The Nd:YAG and $CO_2$ lasers have wavelengths in the nonvisible spectrum. Accordingly, a helium-neon or diode laser (632 nm, red) is typically coupled with them to use as a beam aiming guide and to aid in focus.

## TABLE 7.2
## Laser Characteristics

| TYPE | LASING MEDIUM | WAVELENGTH (nm) | COLOR | DEPTH OF PENETRATION |
|---|---|---|---|---|
| Argon | Argon gas | 488-512 | Blue-green | 0.5 mm |
| KTP | Potassium titanyl phosphate | 532 | Green | 1-2 mm |
| Nd:YAG | Neodymium-doped yttrium aluminum garnet | 1064 | Near infrared | 3-4 mm |
| $CO_2$ | $CO_2$ gas | 10 600 | Infrared | 0.1 mm |

# *$CO_2$*

The $CO_2$ laser is the most versatile and most widely used laser. All laser energy is either absorbed (producing a tissue effect), scattered, transmitted, or reflected. Soft tissue is about 80% water by volume, which absorbs $CO_2$ laser energy readily, limiting penetration. $CO_2$ laser energy has an absorption depth of ~0.1 mm, which means that all energy is extinguished at this depth. Therefore, what you see is what you get. The $CO_2$ laser is therefore relatively safe and can be used in critical areas where RF energy application would be more dangerous, such as near the bladder, on the lateral side wall near the ureter, and on the bowel serosa. A sharply focused laser beam produces narrow tissue vaporization comparable to an incision made by a scalpel. However, defocusing the beam enlarges the spot, and using the same settings, energy density is reduced to treat a thin surface. The $CO_2$ laser hence provides excellent vaporization and cutting by increasing the energy density and excellent coagulation by defocusing of the beam. The amount of damage caused by heat conduction is directly proportional to the amount of time spent in lasing. Disadvantages of the $CO_2$ laser include production of smoke referred to as “plume,” which needs frequent evacuation to allow adequate visualization of the target.

# *Neodymium:YAG (Nd:YAG)*

Similar to $CO_2$ lasers, Nd:YAG lasers emit an invisible beam requiring an aiming beam for guidance. However, this energy penetrates tissue to greater depths of 3-4 mm, and because the Nd:YAG energy scatters in tissue before being absorbed by its target, the thermal damage is greater than that of $CO_2$. Poorly

absorbed by water, it is not as good for vaporization, but it has much better coagulation properties. Because of its depth of penetration and its performance in a liquid environment, it was used to advantage in the early days of hysteroscopic procedures, including endometrial ablation. Although this laser fiber is typically used in a noncontact technique, adding a sapphire tip to the end of the fiber, the laser energy can be focused and converted into heat and used in a contact mode. This improves its vaporization abilities, but the tips need to be cooled with gas or liquid through the fiber.

### *KPT and Argon*

The KTP and argon lasers have similar wavelengths in the visible light spectrum and are delivered via a fiberoptic fiber. The advantages of these lasers over the $CO_2$ laser include selective absorption by hemoglobin and other pigmented tissues and less plume production. These lasers produce a moderate scatter, 100 times that of the $CO_2$ laser, resulting in significantly reduced cutting ability but substantially increased coagulation effectiveness.

The main disadvantage is the need to wear special tinted glasses that distort the view of the pelvis and make it difficult to visualize small implants of endometriosis.

## Laser Safety

Lasers have been used in gynecologic surgery for nearly 40 years. Although there has generally been a good safety record, there is great potential for injury. It is recommended that surgeons wishing to use laser technology undergo both didactic and practical training in laser use. There are also a few guidelines that should be kept in mind related to use of laser technology:

- All operating room personnel should wear protective safety glasses, matched for the wavelength of the laser(s) used—including any aiming beams.
- Place an appropriate warning sign on the door of the operating room indicating when lasers are being used.

- When the laser is not actively being fired, it should be placed in standby mode.
- Drapes near the operative field should be flame resistant and kept wet if possible.
- Adequate suction should be available to collect all plume produced by laser use.
- The surgical team should be aware of the specific tissue interactions of the laser being used. It is much easier to cause damage to a vessel or ureter when using deep penetrating energy such as that produced by the Nd:YAG laser than when using the $CO_2$ laser energy.
- Equipment maintenance is important. Fibers used to transmit laser energy are delicate and can break, deliver laser energy at the break point, and potentially injure the patient and/or operating room personnel.

# SPECIAL SURGICAL SITUATIONS

## Pregnancy

It is thought that using electrosurgical devices in a pregnant patient has no untoward effect on the fetus at any stage of development. Owing to the dispersion effect of the electrolyte-rich amniotic fluid in which the fetus is bathed, it is thought to be protected due to low current density. Just as the output frequency of all electrosurgical generators is above the Faradic effect (the level that stimulates muscle contraction) for adult electrosurgery, the same is true for the fetus.

During a cesarean section, one concern is the accidental touching of an activated electrode to the fetus, which causes tissue heating. This does not mean that the usual technique of making an incision in the uterus would preclude using an electrosurgical incision, but rather that a “backstop” under the incision line, between the amniotic membrane and the muscle wall, should be in place. Although using a nonconductive material, such as a plastic suction tip, may seem wise, a metal ribbon retractor also can be used because it has a large surface area serving to diffuse the current

density. Caution should be exercised when using the gloved finger of the surgeon as a backstop because if open activation is used, the accumulated voltage at the tip may spark across the glove, creating a hole and potentially an unintended injury.

## Body Piercing and Prosthetic Implants

There have been no documented electrosurgical injuries reported in the literature in relation to body piercing. Nonetheless, faulty instrument insulation can theoretically transmit current from the surgical active electrode to the metal object, causing a skin burn. Therefore, guidelines from nursing organizations, among others, recommend removal of umbilical and labial piercings prior to a surgical procedure when possible. It is not necessary to remove piercings or other metal jewelry distant from the operative site. These objects are too far away from the active electrode and out of the circuit to achieve substantial current density. If removal of rings and/or piercings is not desired or possible, then taping the metal object down to the skin to create the greatest surface area contact will decrease current density and minimize any potential risk.

The same principles apply to metal-implanted prosthetic devices. The large surface area would minimize the potential of patient burn, and there have been no reported adverse patient events related to prosthetic devices and electrosurgery. It is noteworthy that the overlying scar has more potential for affecting the electrical circuit through increased resistance and that is minimal as well. Jewelry and piercing concerns are only applicable to monopolar electrosurgery and should never be a concern when using bipolar or harmonic devices.

## Implantable Devices

Any implanted cardiac pacemaker, implantable cardioverter-defibrillator, resynchronization device, or ventricular assist device is referred to as a cardiac implantable electronic device (CIED). The nature of any device type and patient reliance on that device must be

investigated preoperatively. Most hospitals have resources that can provide insight and management of these devices when patients present for surgery. Failure to fully understand the device and the manufacturer recommendations, and act accordingly, can lead to adverse outcomes. The potential for electromagnetic interference with CIEDs depends upon the distance from the circuit (from active to dispersive electrode), the waveform and type of RF used, and the type and insulation of the CIED itself. Attention must be paid to place the dispersive electrode in a location such that the path between the active and dispersive electrodes does not travel near the CIED generator or leads. With this precaution, the risk of interference is low (although there is at least some potential for interference, as the RF circuit does not travel linearly between the active and dispersive electrode).

Possible adverse effects of CIEDs with electrosurgery include permanent damage to the device, inability of the device to function properly, resetting of the device, and inappropriate delivery of implantable cardiac defibrillator (ICD) therapy (potentially leading to complications including hypotension, tachyarrhythmia or bradyarrhythmia, myocardial tissue damage, and myocardial ischemia or infarction). When planning a surgical procedure in a patient who is heavily dependent on the CIED, bipolar devices should be considered in lieu of monopolar instruments (where the circuit is limited to tissue between the tips of the forceps and stray RF energy is rare).

Preoperative management of the CIED may include reprogramming or disabling algorithms and suspending antitachyarrhythmia functions. Clinical magnets positioned over the CIED can change pacing to an asynchronous mode in pacemakers and suspend tachycardia therapies in ICDs. However, magnets should not be routinely used over an ICD. Temporary pacing and defibrillation equipment should be immediately available before, during, and after the procedure.

Although continuous monitoring by EKG is critical, that signal can also be subject to electromagnetic interference, which can complicate detection of CIED malfunction. Thus, peripheral perfusion

by pulse oximetry or invasive arterial waveform should also be monitored.

There are noncardiac devices using electric current that could potentially be affected by RF energy during electrosurgery. These include neural stimulators and gastric neurostimulators used to treat gastroparesis. Minimizing interference with these devices is desirable. However, the consequences of malfunction are not immediately life threatening, as with CIEDs.

# HAZARDS OF ELECTROSURGERY IN THE OPERATING ROOM

## Fire Hazards

The operating room environment presents an increased opportunity for fires due to the proximity of the risk trilogy: an ignition source (active electrode), oxidizers (compressed pure oxygen or room air, which contains 21% oxygen), and a fuel source. A plethora of fuel sources are present in the operative space, including alcohol, surgical preps, drapes, surgical gowns, surgical sponges, and patient skin or hair. Further, in the setting of monitored anesthesia care, gasses delivered via mask or nasal cannula, which is heavier than room air, may collect under drapes near the surgical field. A spark jump from an active electrode can potentially ignite any of these potential fuel sources resulting in fire. Thus, it is imperative to inspect the integrity of electrosurgical instruments, allow time for surgical site prep to dry completely, and employ good electrosurgical technique to minimize fire risk.

In the event of an operating room fire, “breaking sterile environment” should be the last concern. It is imperative that the fire be extinguished as rapidly and safely as possible. All electrosurgical sources should be turned off, burning items (drapes, sponges, etc.) should be removed from the patient if possible, and an appropriate fire extinguisher should be deployed. Importantly, liquid-based fire extinguishers should not be used in the event of an electrical fire, and those utilizing fire-retardant powder should not be used in

proximity to an open wound. The extinguisher of choice in this setting is one that delivers a nontoxic fire-retardant gas.

## Surgical Plume

Without, electrosurgery and lasers create a plume of surgical byproducts from heating, vaporizing, fulgurating, or desiccating tissue. The resulting surgical smoke contains a plethora of toxic chemicals and hydrocarbon residues, many of which are considered “priority pollutants” by the EPA. Additionally, biological contaminants like blood, viral DNA, and bacteria have been identified in surgical plume. While the viability and infectious potential of viral or bacterial contaminants so transmitted are debatable, such entities have been identified within an electrosurgical plume. Notably, the concentration of aerosolized contaminants is proportional to the power settings, current density, length of active electrode activation, and the amount of tissue disrupted.

Everyone in the operating room is exposed to some degree of surgical smoke at variable intervals throughout laparotomy and vaginal surgical procedures. Without question, there is exposure every time laparoscopic instruments are passed in and out of trocars and even more with release of pneumoperitoneum during or after a procedure. Surgical masks are designed more to protect the patient from the operating room staff rather than to provide protection to the surgical team. Indeed, over three-fourths of particulate matter in surgical smoke is 1.1 μm or less, well below the 5-μm filtering capability of the standard surgical mask. It would be unrealistic (not to mention uncomfortable) to wear an N95 respirator during surgical cases, and even then, there may be questions regarding proper fit throughout. Thus, the surgical mask should never be considered the primary protection from electrosurgically generated smoke.

There are an increasing number of active and passive smoke evacuation systems available for both open and laparoscopic procedures. Many of these devices are certified for ultra-low penetration air (ULPA) filtration, able to remove particles as low as 0.12 μm in diameter. However, too little consideration is typically afforded considerations for plume evacuation. Such a plan should

always be a part of the preoperative preparation of every surgical case and in many US states is mandatory.

## KEY POINTS

- Electrosurgical current (flow of electrons) is directly related to voltage (electromotive force) and inversely related to impedance (resistance to flow of electrons when using AC) and follows three rules: (1) electricity must complete a circuit or it will not flow; (2) electricity goes to the ground; and (3) electricity follows the path of least resistance.
- Electrosurgical generators deliver sinusoidal current waveforms with variants of current and voltage as a continuous output (CUT), a highly interrupted output (COAG), or a moderately interrupted output (BLEND).
- Specific tissue effects can be achieved by using variants of waveform, tissue contact vs noncontact, size and shape of the active electrode, and movement speed of the active electrode (dwell time). The educated surgeon can integrate these variables to achieve the desired result.
- With monopolar systems, use a return electrode monitoring system with dispersive electrode close to the operative site on a clean, dry, shaved area, avoiding bony prominence and scar tissue, with the longest edge facing the operative site.
- To avoid capacitive coupling, do not secure instrument cords to metal clamps, avoid open activation of electrodes, and activate electrodes in short bursts (about 3 seconds).
- Consider using bipolar methods, which deliver an uninterrupted waveform; consider using a current flow meter to confirm complete desiccation of tissue.
- Consider using bipolar energy for patients with pacemakers and other implanted cardiac devices. If monopolar must be used, follow safety advice from the implant manufacturer.

- When using lasers intraoperatively, ensure everyone in the room has eye protection appropriate for the type of laser and guide beam being used.
- Inspect the integrity of electrosurgical instruments, allow surgical preps to dry completely, have a flame-retardant gas fire extinguisher available, and use good technique to minimize risk of operative room fires.
- Routinely employ either passive or active devices for plume evacuation to protect the surgical team from biological and inorganic contaminants produced when using surgical energy sources.

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# CHAPTER 8

# INCISIONS FOR GYNECOLOGIC SURGERY

James J. Burke II

**Physiology of Wound Healing**
Hemostasis
Inflammation
Proliferation
Remodeling
**Abdominal Incisions**
Transverse Incisions
Vertical Incisions
**Incisions for Obese Patients**
Midline Incision for the Obese Patient
Panniculectomy and Abdominoplasty
**Perineotomy Incisions**
Schuchardt Incision
**Closure of Vertical Incisions**
Use of Drains
Delayed Primary and Secondary Closure
Negative Pressure Wound Therapy
**Necrotizing Soft Tissue Infections**

**Wound Dehiscence and Evisceration**

**Incisional Hernia**

One of the lasting marks of any abdominal surgery, and most noticeable to the patient, is the scar made by the incision. In selecting an incision, the gynecologist must take into consideration the underlying pathology prompting the surgery, the suspicion of malignancy, the absence or presence of upper abdominal disease, and the underlying comorbid state of the patient. Although there are many types of incisions for gynecological surgery, selection of any incision must be highly individualized.

Selection of an incision should not be affected by patient choice to preserve cosmesis if it will compromise the surgical approach. Conversely, unduly large or poorly positioned incisions may increase the likelihood of infection, herniation, or dehiscence, as well as an unsightly scar. During the surgical consenting process, the patient should be counseled on the location of the incision, the rationale for the particular incision, and any possible complication that may arise from the planned incision.

# PHYSIOLOGY OF WOUND HEALING

When making a surgical incision, tissue is violated to gain access to diseased organs and results in an acute wound. This insult breaks the barrier that protects humans from invasion by bacteria and other pathogens. Wound healing is a regulated and coordinated biological process, which employs multiple cellular and extracellular pathways to restore tissue integrity and thus the barrier. These controlled, acute wounds heal in a progressive, systematic, and balanced repair process, consisting of four phases: hemostasis, inflammation, proliferation, and tissue remodeling (**FIG. 8.1**).

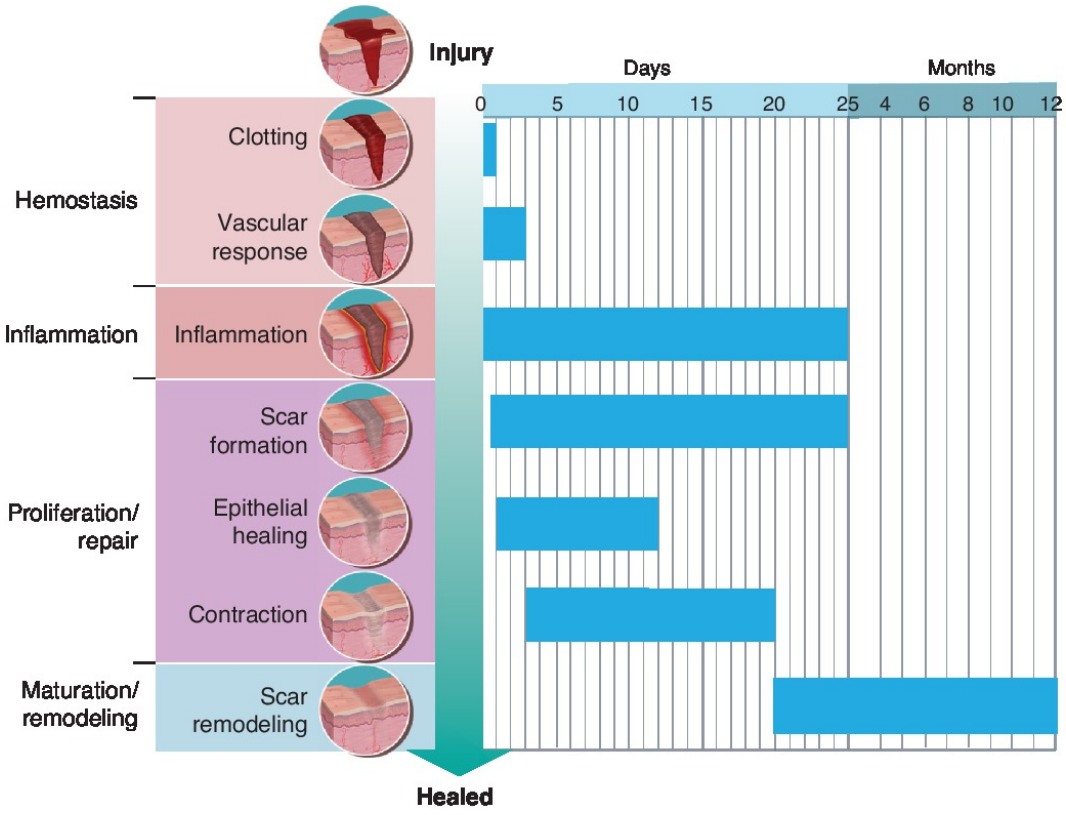



**FIGURE 8.1** Steps of wound healing.

# Hemostasis

The hemostatic phase is initiated immediately upon vascular injury during creation of the surgical incision. Smooth muscle in the circular layer of arterial vessels contracts, mediated by increasing cytoplasmic calcium levels. This reduced perfusion leads to tissue hypoxia and acidosis causing production of vasoactive metabolites such as adenosine and nitric oxide. Subsequently, the smooth muscle will relax, and the arterial vessels will vasodilate. Simultaneously, histamine is released from mast cells, increasing vasodilatation and vascular permeability, allowing inflammatory cells into the extracellular space around the wound.

A blood clot is created due to injury of the endothelium, whereby the intrinsic and extrinsic clotting cascades begin, and platelet activation occurs. The intrinsic pathway starts when endothelial damage exposes the subendothelial tissues to blood, resulting in the

activation of factor XII (Hageman factor). Through a series of steps, factor X is activated, converting prothrombin to thrombin and fibrinogen to fibrin resulting in development of a fibrin plug. Simultaneously, the extrinsic pathway starts when endothelial damage results in tissue factor being exposed to the bloodstream. This exposure results in the activation of factor VII and the rest of the extrinsic pathway leading to the activation of thrombin.

Finally, platelets change morphology due to activation of thrombin, thromboxane, or adenosine diphosphate (ADP). This conformational change causes platelets to secrete the contents of their alpha and dense granules. These granules contain multiple growth factors and cytokines necessary for the regulation of wound healing, making platelet activation a crucial step of wound healing. The activated platelets adhere and clump where collagen is exposed creating a platelet plug to stop bleeding. This plug is further strengthened by fibrin, von Willebrand factor, and actin and myosin filaments contained within platelets. Activated platelets are critical to wound healing, secreting over 300 signaling molecules that influence and modulate the function of platelets, leukocytes, endothelial cells, and cells necessary to close the wound. In addition to the hemostatic process herein described, injured cell membranes lead to the breakdown of arachidonic acid resulting in potent signaling molecules such as prostaglandins, leukotrienes, and thromboxanes that stimulate the inflammatory response.

# Inflammation

The inflammatory phase starts immediately following formation of the wound and is characterized by an inflammatory cell wound infiltration to prevent infection and clear wound debris. Neutrophils are highly motile cells that infiltrate the wound within an hour of the injury and continue migration into the wound at sustained levels for the first 48 hours. Neutrophils are summoned to the wound through multiple signaling mechanisms such as the complement cascade, interleukin activation, and transforming growth factor beta (TGF-β) signaling. This “bread crumb” trail of activated substances creates a gradient toward the wound that neutrophils follow and is called chemotaxis.

Neutrophils are necessary to clear bacteria and debris from the wound, accomplishing this cleanup through several different mechanisms. Through the process of phagocytosis, neutrophils can directly ingest and destroy foreign particles.

In addition, these cells have a variety of toxic substances (lactoferrin, proteases, neutrophil elastase, and cathepsin) that are released by degranulation and directly kill bacteria and destroy necrotic tissue. Finally, neutrophils can kill bacteria by chromatin and protease "traps," resulting in oxygen free radical production, which combines with chlorine to sterilize the wound. Once they have completed their task, neutrophils undergo apoptosis and are sloughed from the wound or phagocytosed by macrophages.

Macrophages arrive in the wound 48-72 hours after the injury, attracted by chemical messages released from platelets and damaged cells. These cells coordinate transition to the proliferative phase of wound healing by releasing additional growth factors, mediating angiogenesis and fibroplasia, and synthesizing nitric oxide. Lymphocytes appear in the wound after 72 hours and are key to regulating wound healing through productions of the extracellular matrix (ECM) scaffold and collagen remodeling. This phase of wound healing will last as long as needed so that the wound bed is clean and bacteria-free. However, protracted inflammation can lead to extensive tissue damage and delayed proliferation and result in the formation of a chronic wound (**TABLE 8.1**).

## TABLE 8.1
## Cells Involved in Wound Healing

| CELL TYPE | TIME OF ACTION FROM INJURY | FUNCTION |
|---|---|---|
| Platelets | Seconds | Thrombus formation<br>Activation of coagulation cascade<br>Release of inflammatory mediators |
| Neutrophils | Peak at 24 h | Phagocytosis of bacteria<br>Wound débridement<br>Release of proteolytic enzymes<br>Generation of oxygen free radicals<br>Increased vascular permeability |
| Keratinocytes | 8 h | Release of inflammatory mediators<br>Stimulation of keratinocyte migration<br>Neovascularization |
| Macrophages | 48-72 h | Phagocytosis of neutrophils<br>Release of inflammatory mediators<br>Neovascularization<br>Growth factor release |
| Lymphocytes | 72-120 h | Regulates proliferative phase of wound healing<br>Collagen deposition |
| Fibroblasts | 120 h | Synthesis of granulation tissue<br>Collagen synthesis<br>Production of ECM<br>Release of proteases<br>Release of inflammatory mediators |

ECM, extracellular matrix.
Adapted from Singh S, Young A, McNaught CE. The physiology of wound healing. *Surgery (Oxford)*. 2017;35(9):473-477. Copyright © 2017 Elsevier, with permission.

# Proliferation

Once hemostasis has been achieved and debris and bacteria have been cleared from the wound, the defect can begin repair. This proliferation occurs through a complex process of angiogenesis, formation of granulation tissue, collagen deposition, epithelialization, and wound retraction. Angiogenesis starts once the hemostatic plug is formed with release of TGF-β, platelet-derived growth factor (PDGF), and fibroblast growth factor (FGF). In response to hypoxia, vascular endothelial growth factor (VEGF) is released and works with other cytokines to repair damaged blood vessels through neovascularization. Mixed metalloproteinases (MMPs) are a family of enzymes activated by invading neutrophils in hypoxic tissue. These enzymes mediate angiogenesis through liberation of VEGF and remodeling the ECM. As the process of angiogenesis progresses, a rich network of new capillaries is formed. These vessels are “leaky” and weak and result in increased edema in the wound, giving the pink appearance of healing granulation tissue.

Fibroblasts are stimulated to proliferate by growth factors released from the hemostatic clot, immediately following the wound insult. These fibroblasts migrate to the wound in response to TGF-β and PDGF signaling, and once in adequate numbers, usually around day 3, the fibroblasts begin to lay down ECM proteins (hyaluronan, fibronectins, and proteoglycans) and subsequently produce collagen. Granulation tissue produced at this time consists of a wide range of collagen types, but mostly immature type III collagen, which is a weak collagen as compared to the more mature type I collagen. This collagen production provides the initial strength to the tissue and wound. Once adequate ECM has been laid down, fibroblasts change to myofibroblasts, developing pseudopodia, which allows the myofibroblasts to connect to surrounding proteins, fibronectin, and collagen to assist in wound contraction. These myofibroblasts also promote angiogenesis through mediation of MMP activity.

When the wound is closed by primary intention, collagen production is maximal by day 5 and can be palpated under the skin as the “wound ridge.” Epithelial cells migrate from the edges of the wound very soon after the initial injury. An embryological process, epithelial-mesenchymal transition (EMT), allows epithelial cells to gain motility to travel across the wound surface. For wounds that are closed by primary intention, this phase of epithelialization can occur within 24 hours. Changes in cytokine concentrations result in epithelial cells converting from a motile phenotype to a proliferative phenotype in order to repopulate epithelial cell levels to complete wound repair. For wounds healing by secondary intention, the defect can be large, and this process of epithelialization will require significant wound contraction to occur first. Seven days after the injury, the wound will begin contracting, driven by myofibroblasts. Contraction can occur at a rate of 0.75 mm/d, leading to shortened scars. The wound shape contributes to the speed at which a wound will contract, with linear scars contracting the fastest and circular scars the slowest.

# Remodeling

From day 8 through year 2, wound remodeling and maturation occur through a balance of synthesis and degradation. Initial deposition of collagen is disordered, and over time, remodeling of collagen at areas of increased stress allows for increased tensile strength. By the 3rd week, type III collagen has been replaced by type I collagen, which is the most common type of collagen in the human body. Despite this remodeling, wounds will never reach the same level of strength of the original tissue, gaining only 50% of the original tensile strength at 3 months and 80% of the original tensile strength after remodeling is completed. The level of vascularity decreases as the scar matures, changing from a pink color to gray over time.

Disruption of one or more of these phases may have two distinct damaging consequences: the development of a chronic wound or the formation of a hypertrophic scar or keloid. Chronic wounds are defined as barrier defects that have not proceeded through orderly and timely reparation to regain structural and functional integrity and

exceed 12 weeks of healing from the inciting injury. Hypertrophic scars and keloid formation are forms of excessive wound healing characterized by an initial inflammatory process, upregulated fibroblast function, and excessive ECM deposition. Hypertrophic scars tend not to overgrow the original wound boundaries and are most commonly self-limited, fading over time. These scars consist mostly of type III collagen arranged in parallel with the skin surface. In contrast, keloid formation is an abnormally vigorous scarring that tends to extend beyond the edges of the original wound and does not regress. These scars can cause hyperesthesia and pruritus and occur more commonly among African Americans, Asians, and dark-skinned individuals. These scars consist of disorganized type I and III collagen depositions.

Factors negatively affecting proper wound healing include: age, comorbid conditions such as cardiac disease, connective tissue disorders, diabetes, and liver diseases, and lifestyle factors such as nutritional status, obesity, smoking, and illicit drug usage. Prior irradiation, and concurrent chemotherapy, steroid, and nonsteroidal anti-inflammatory drug (NSAID) usage will also affect proper healing. In addition to these factors, bacterial burden can impact wound healing and interrupt the progressive, ordered repair process. Bacteria colonize a wound within 48 hours, have low virulence, and do not invade the tissue. A critical threshold of $10^5$ bacteria has been proposed to delineate bacterial colonization from a clinically relevant infection that can impede wound healing. Contamination within a wound is defined by infection with nonreplicating bacteria, whereas colonization is defined as the presence of replicating bacteria that adhere to the wound without causing tissue damage; both do not delay wound healing. However, critical colonization may delay wound healing. In acute wounds, bacteria exist as free-floating planktonic organisms and must be rapidly controlled to prevent tissue destruction and wound sepsis. Bacteria in chronic wounds do not exist as planktonic organisms but rather as biofilms able to resist the host inflammatory cascade and antibiotic therapy.

Surgical wounds are controlled forms of trauma that can be categorized on the basis of degree of contamination to predict the risk of wound infection after surgery. The risk of wound infection is

directly related to the classification of wounds (**TABLE 8.2**). Most abdominal procedures performed by gynecologists include a hysterectomy, and whenever the vagina is entered, the procedure is classified as a clean-contaminated procedure.

## TABLE 8.2
## Wound Classification

| CLASS | CATEGORY | DEFINITION | WOUND INFECTION RATE (%) |
|---|---|---|---|
| I | Clean | Wounds are made under ideal operating room conditions. The procedures are usually elective, and no entry is made into the oropharyngeal cavity or lumen of the respiratory, alimentary, or genitourinary tract. Inflammation is not encountered, and no break in technique occurs. The wounds are always primarily closed and seldom drained. Almost 75% of all operations are included in this group. | 1-5 |
| II | Clean-contaminated | Wounds occur from entry into the oropharyngeal cavity, respiratory, alimentary, or genitourinary tract without significant spillage. Clean wounds are included in this category when there is a minor break in surgical technique. These procedures include about 16% of all operations. | 3-11 |
| III | Contaminated | This category includes open, fresh, and traumatic wounds, operations with a major break in sterile technique, and incisions encountering acute, nonpurulent inflammation, such as in cholecystitis or cystitis. | 4-17 |
| IV | Dirty | Old (>4 h) traumatic wounds, perforated viscera, or operations involving clinically evident infections are included in this category. Wounds containing foreign bodies or devitalized tissue are also considered dirty. | 5-27 |

From Ortega G, Rhee DS, Papandria DJ, et al. An evaluation of surgical site infections by wound classification system using the ACS-NSQIP. *J Surg Res*. 2012;174(1): 33-38; Cruse PJE, Foord R. The epidemiology of wound infection: a 10-year prospective study of 62,939 wounds. *Surg Clin North Am*. 1980;60:27; Culver DH, Horan TC, Gaynes RP, et al. Surgical wound infection rates by wound class, operative procedure and patient risk index. National Nosocomial Infections Surveillance System. *Am J Med*. 1991;91:152S.

# ABDOMINAL INCISIONS

Abdominal incisions used for most gynecologic procedures can be divided into transverse or vertical incisions. For extraperitoneal incisions and access to organs not associated with the female genital tract, modifications of oblique incisions are sometimes used. Because of the ease and rapid entry, the abdomen was originally routinely opened by a midline incision in the linea alba. One of the first successful abdominal operations was performed by McDowell in 1809. In the early days of abdominal surgery, transverse incisions

were generally avoided because they were more time consuming. An unfounded fear was that transection of the rectus muscle would leave a defect due to retraction of the muscle. However, this is not the case as we now know that the adherence of the recti musculature to its anterior fascia prevents retraction. In the late 1800s and early 1900s, several transverse incisions were developed, such as the Küstner, Pfannenstiel, Maylard, and Cherney incisions. Most of the transverse incisions used for pelvic surgery are identified by the name of the surgeon who first described them, whereas the few vertical abdominal incisions have no such eponyms.

Because of concerns about wound complications, a prior dictum was that incisions of the abdominal skin not be made with electrosurgery. A recent meta-analysis evaluating wound complication rates between incisions made with a scalpel or electrosurgery found no difference in wound complications regardless of method of incision creation. The authors determined that current evidence suggests that making an abdominal incision with electrosurgery may be as safe as using a scalpel.

Older practice supported using a separate scalpel for skin incisions and changing scalpels when continuing incisions into deeper layers. Discarding the skin knife, now considered an archaic practice, has not been shown to reduce wound infection rates but instead leaves an extra “sharp” on the operative field, which may injure members of the health care team. In a randomized prospective study, the rate of postoperative wound infections was not different after the use of one or two scalpels for the incision. The same scalpel used on the skin can be safely used for subcutaneous and deep incisions.

# Transverse Incisions

Transverse incisions for pelvic surgery are attractive because they produce the best cosmetic results. Additionally, low transverse incisions are as much as 30 times stronger than midline incisions, are less painful for patients, and result in less interference with postoperative respiration. Historically wound dehiscence has been

reported to occur more commonly with vertical incisions. The older literature suggests that wound evisceration was three to five times more common and hernia formation was two to three times more common with vertical incisions. Recent studies, however, have shown no difference in the risk of wound dehiscence or even a slight advantage for midline incisions. A large study, completed at Hutzel Hospital in Detroit by Hendrix and colleagues, found that there was no difference in fascial dehiscence between transverse (Pfannenstiel) and vertical incisions.

Transverse incisions have certain associated disadvantages. They are more time consuming to perform and relatively more hemorrhagic. Occasionally, nerves are divided, and division of multiple layers of fascia and muscle can result in formation of potential spaces with subsequent hematoma or seroma formation. The ability to explore the upper abdominal cavity adequately is compromised with most low transverse incisions.

## *Pfannenstiel Incision*

Most surgeons would agree that the Pfannenstiel incision provides the best wound security of all gynecologic incisions. The cosmetic results are excellent, but exposure is limited (especially to the upper abdomen). This type of incision should be used in select patients with certain gynecologic malignancies. Similarly, this incision should be used selectively for patients in whom pelvic exposure is needed in nonmalignant.

The original, true Pfannenstiel incision is described as a transverse incision that is slightly curved (concavity upward) and may be made at any level suitable to the surgeon. This incision is usually 10-15 cm long. Details for performing this incision are described in **FIGURE 8.2A-D**. Separating the rectus in the midline avoids the necessity of dissecting the subcutaneous fat away from the anterior rectus fascia, as is done in the Küstner incision. It separates the perforating nerves and small blood vessels, which enter the fascia from the underlying muscles to supply the fascia, although it possibly weakens the incision.

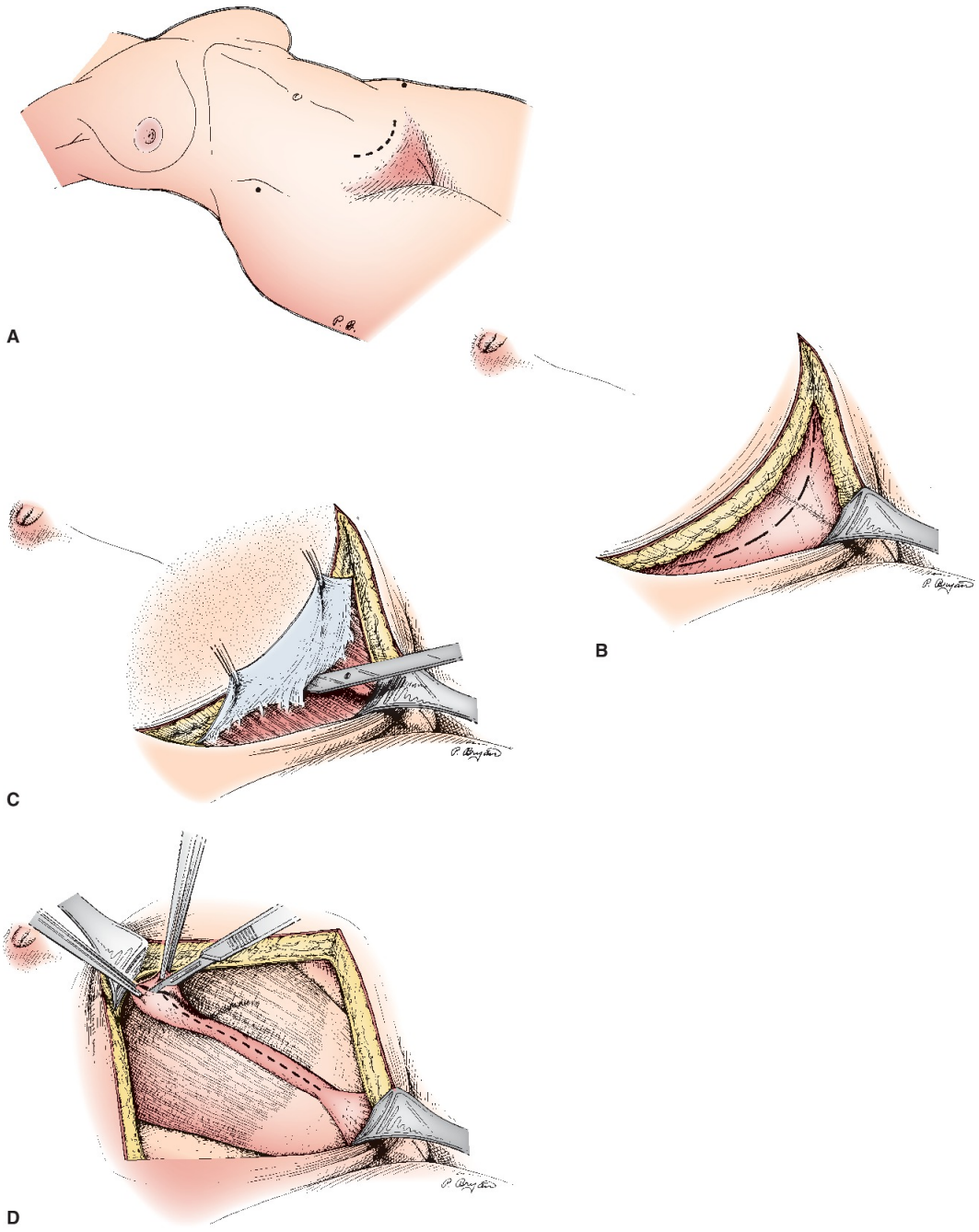



**FIGURE 8.2** **A.** The skin incision for a Pfannenstiel incision is elliptical just above the symphysis pubis. **B.** The skin, subcutaneous fat, and fascia of the abdominal wall are incised transversely. **C.** The fascia is

separated from the rectus muscle superiorly, inferiorly, and laterally. Small perforating vessels require ligation or coagulation. **D.** The rectus muscles are separated, and the peritoneum is incised in the midline.

If the Pfannenstiel incision is extended laterally beyond the edge of the rectus muscles and into the substance of the external and internal oblique muscles, injury to the iliohypogastric or ilioinguinal nerves can occur, with resulting neuroma formation. In addition, closure of this extended fascial incision can entrap these nerves in either the closing suture or surrounding scar tissue. To avoid these nerve injuries in laterally extended incisions, including a Cherney or Maylard incision, the lateral extensions should have sutures placed only in the external oblique fascia.

The fascia can be closed with a running technique in patients with clean wounds or clean-contaminated wounds. Polyglycolic acid, polyglactin 910 (such as Vicryl™), or one of the delayed absorbable sutures can be used. Subcutaneous sutures are usually unnecessary, and the skin is closed with a subcuticular suture (preferably monofilament), reinforced with surgical tape (eg, Steri-Strips™), skin glue, or staples.

## *Küstner Incision*

Some surgeons advocate a Küstner incision, incorrectly referred to as a modified Pfannenstiel incision. The slightly curved transverse skin incision begins below the level of the anterosuperior iliac spine and extends just below the pubic hairline, through subcutaneous fat, down to the aponeurosis of the external oblique muscle and the anterior sheath of the recti musculature, in the same manner as all other transverse incisions. The superficial branches of the inferior epigastric artery and vein may be encountered in the subcutaneous fat at the lateral margin of the incision. When encountered, they can be ligated or sealed with electrocautery. The fascia is cleaned

superiorly and inferiorly until a sufficient area is exposed from the region of the umbilicus to the symphysis to permit an adequate vertical incision in the linea alba. Excessive separation of the fat from the fascia in the lateral margins of the incision is unnecessary and can provide sites for small postoperative hematomas or seromas. Separation of the rectus muscles and entrance into the peritoneum are performed in the same manner as for the ordinary midline incision. Because of the importance of obtaining adequate hemostasis in the subcutaneous fat of the skin flaps, this incision is definitely more time-consuming than the low midline incision or the Pfannenstiel incision. It offers little or no tensile strength advantage, and its extensibility is severely limited. If this incision is used, consideration of subcutaneous, closed suction drainage should be given, due to the large amount of "dead space" created, although this practice is controversial (**FIG. 8.3A** and **B**).

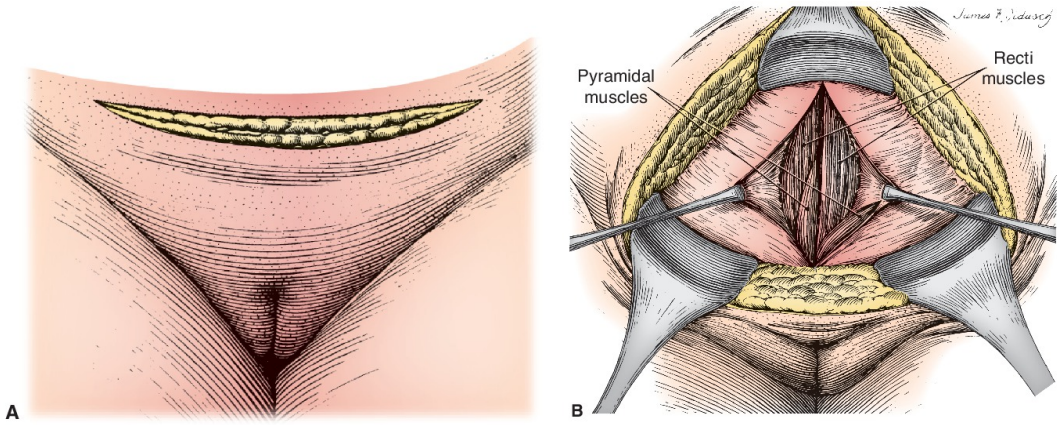


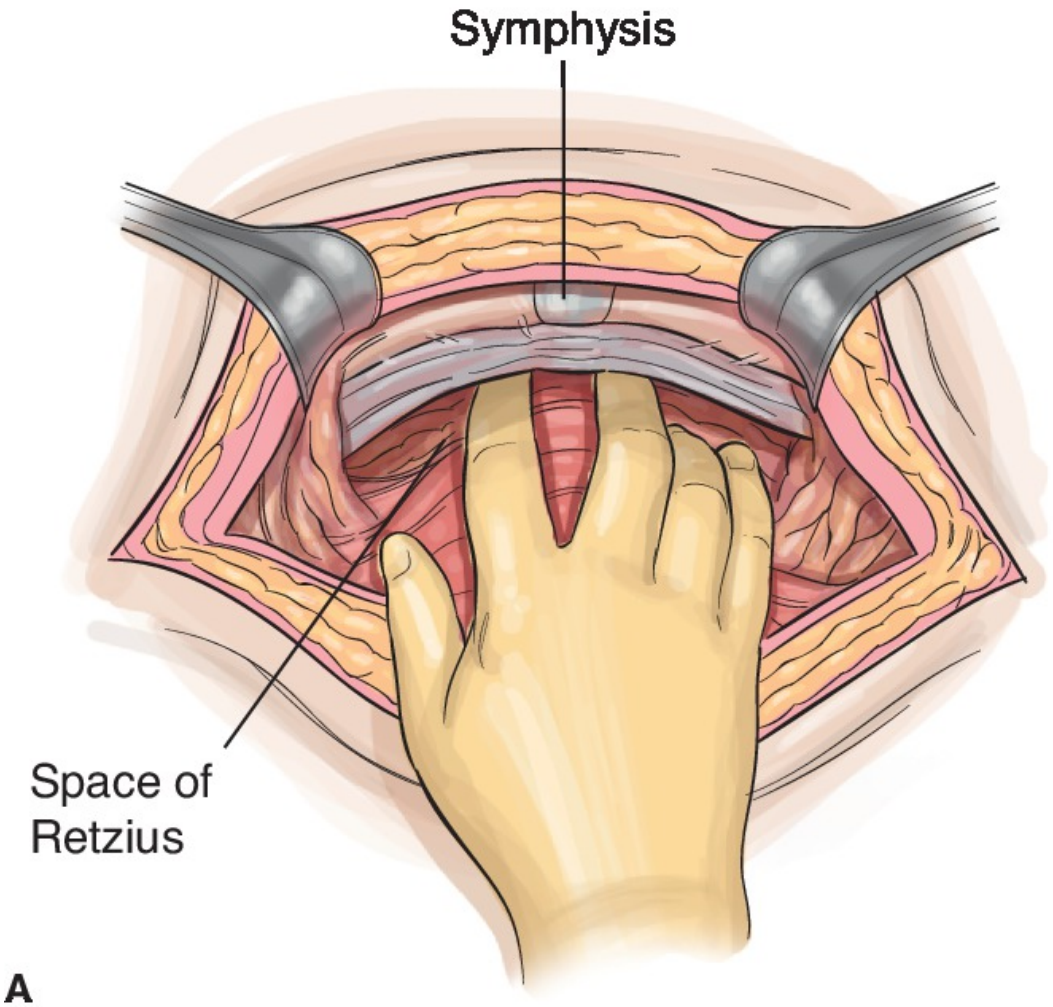

**FIGURE 8.3** Küstner incision. **A.** Skin incision just below the hairline. **B.** Midline incision through fascia, exposing rectus and pyramidalis muscles. The rectus muscles are retracted laterally, and the peritoneum is incised in the midline.

# *Cherney Incision*

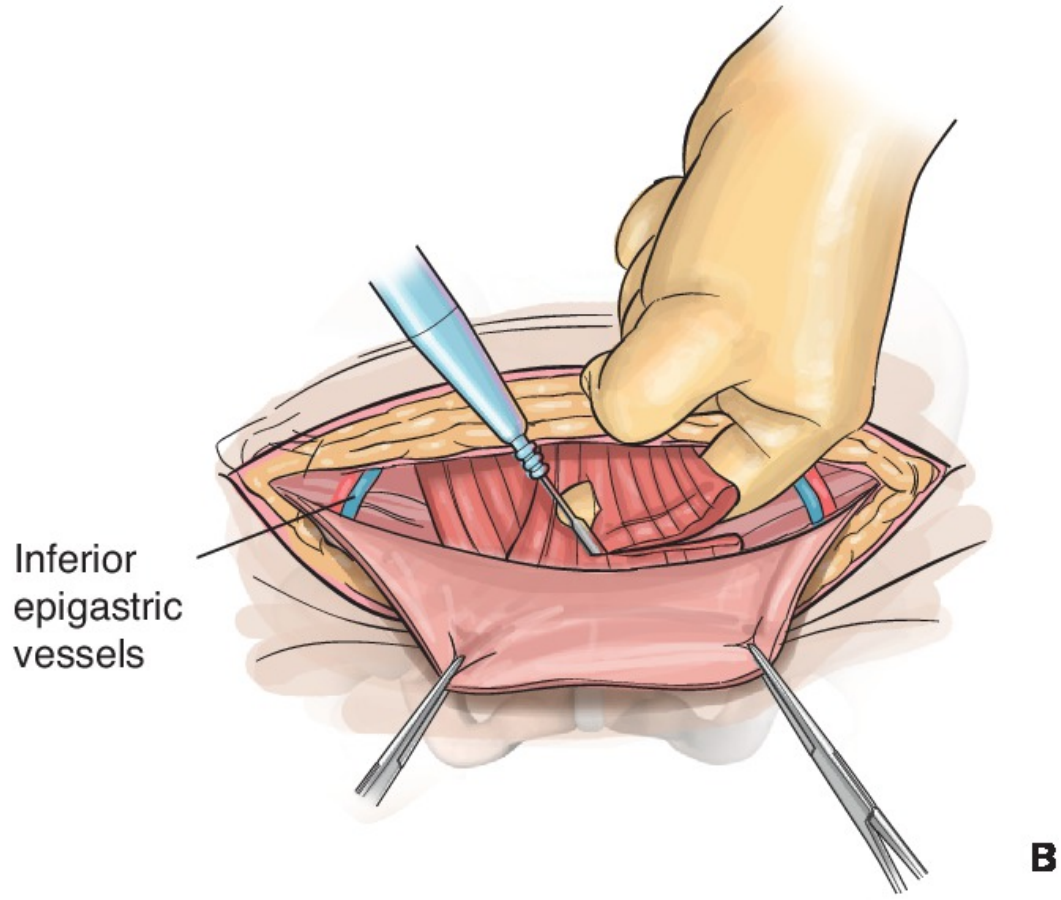
The Cherney differs from the muscle-dividing Maylard incision by the location of transection of the rectus muscles. In both incisions, the skin and fascia are divided transversely as with a Pfannenstiel incision, but Cherney advocated freeing the rectus muscles at their tendinous insertion into the symphysis pubis. The rectus muscles are then retracted cephalad to improve exposure. The transverse Cherney incision is about 25% longer than a midline incision measured from the umbilicus to the symphysis.

The Cherney incision provides excellent access to the space of Retzius and excellent exposure of the pelvic side wall. Occasionally, the surgeon who uses a Pfannenstiel incision finds the incision inadequate for exposure for hemostasis or not large enough to expose areas of associated abnormal conditions deep in the pelvis. Under these circumstances, the safest approach is not to transect the rectus muscles halfway but to perform a Cherney incision. Partial incision of the rectus muscle can lead to injury of the inferior epigastric vessels on the lateral border of the rectus muscles. If conversion to a Maylard is attempted after a previous Pfannenstiel incision, the anterior rectus sheath will have already been widely separated from the rectus muscles. In this case, the ends of the muscle are likely to retract and will not reunite when the edges of the fascia are later reapproximated. It may be necessary to reapproximate the rectus muscle ends with horizontal mattress sutures, which may be difficult due to the retraction, and which risks hematoma formation with suture placement in the muscle ends.

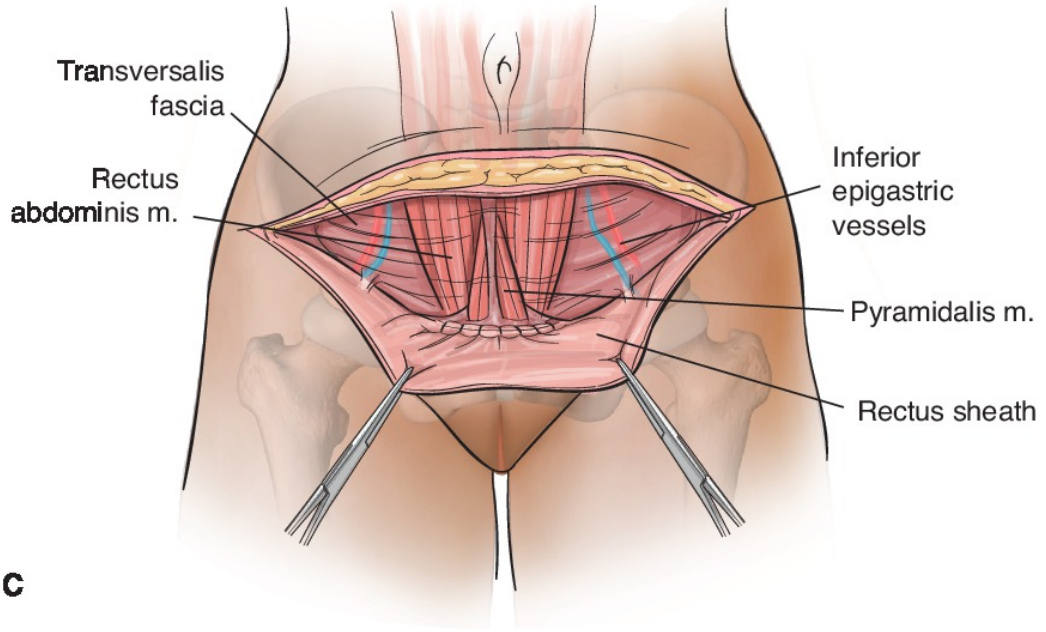
Even if the peritoneum is already opened, the space of Retzius can be bluntly dissected to provide exposure for performing a Cherney incision (**FIG. 8.4A-C**). The inferior epigastric vessels, which course more laterally on the rectus muscles, are identified. The pyramidal muscles are sharply dissected. The fibrous tendinous rectus muscles are then dissected sharply from their insertion into the symphysis pubis. This can be performed with cautery. Bleeding is negligible in this area, and the inferior epigastric vessels do not need to be ligated. The peritoneal incision can be extended laterally about 2 cm cephalad to the bladder while the vessels are visualized.




A


Inferior
epigastric
vessels

B


Transversalis
fascia
Rectus
abdominis m.
Inferior
epigastric
vessels
Pyramidalis m.
Rectus sheath

C

**FIGURE 8.4** Cherney Incision. **A.** Developing the space of Retzius. The weight of the hand of the operator easily separates the bladder from the overlying symphysis in the relatively bloodless midline. **B.** The finger of the operator is placed posterior to the rectus muscle, and with gentle traction, the muscle is pulled cephalad. The rectus muscle can then be dissected from its insertion at the symphysis by the Bovie device. The peritoneal incision can then be extended laterally, avoiding the inferior epigastric vessels, which are positioned laterally. **C.** Reuniting of the rectus tendons to the inferior portion of the lower flaps. The deep inferior epigastric vessels are positioned along the lateral edge of the rectus musculature.

Transverse incisions, particularly the Cherney and the later-described Maylard, can result in nerve injury. The femoral nerve is particularly at risk when a self-retaining retractor with deep lateral blades is used in these widely extended incisions. If a self-retaining retractor is used with either of these incisions, the lateral blades should only be deep enough to fit under the edges of the incision and not rest on the psoas muscles.

In closing a Cherney incision, the ends of the rectus tendons are united to the inferior portion of the lower flap of the rectus sheath with five or six interrupted delayed absorbable or permanent sutures in horizontal mattress configuration. To avoid osteomyelitis, the rectus muscles should not be sutured to the periosteum of the

symphysis pubis. Fascial closure is then accomplished with a running continuous suture of no. 0 or no. 1 delayed absorbable material, as in the Pfannenstiel. The remainder of the closure is similar to the Pfannenstiel closure, depending on the surgeon's preference.

## *Maylard Incision*

The Maylard incision was originally described by Ernest Maylard in 1907. This incision is a true transverse muscle–cutting incision in which all layers of the lower abdominal wall are incised transversely. The incision provides excellent pelvic exposure and is used by many surgeons for radical pelvic surgery, including radical hysterectomy with pelvic lymph node dissection and pelvic exenteration. Although midline incisions are preferable for patients with suspicious adnexal masses, some patients may be candidates for this more cosmetic incision. Patients must be informed that if malignancy is found, the transverse incision will take the form of a "hockey stick" or "J" incision (**FIG. 8.5**), or a separate upper abdominal incision will be used to evaluate the upper abdominal cavity and retroperitoneal para-aortic nodes.

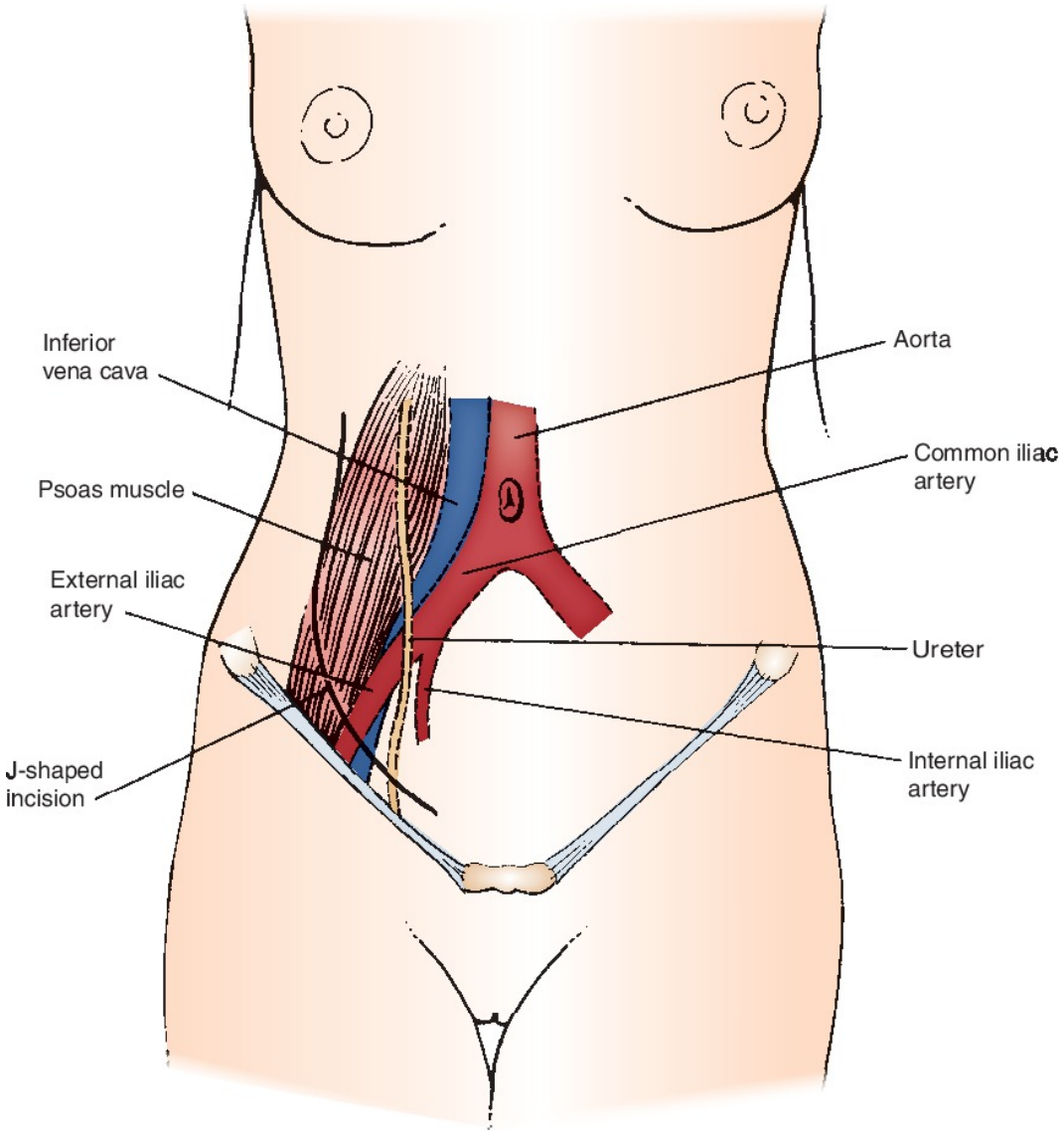



**FIGURE 8.5** J-shaped incision on the *right* is shown in relation to deeper structures, the ureter, iliac vessels, and great vessels. It is initiated about 3 cm cephalad to the umbilicus and is carried inferiorly parallel to the round ligament. (Reprinted from Gallup DG. Abdominal incisions and closures. In: Gallup DG, Talledo OE, eds. *Surgical Atlas of Gynecologic Oncology*. 1st ed. WB Saunders;

1994:43. Copyright © 1994 Elsevier, with permission.)

The Maylard (also called Maylard-Bardenheuer) incision has been modified in several aspects since its original description. Before the skin incision is made, a series of three to four perpendicular markings with a sterile marking pen are made across the planned line of the incision. These markings help later to reapproximate the skin edges. The transverse skin incision is made about 3-8 cm above the pubic symphysis, depending on the indications for surgery and patient age and weight. The skin incision should never be made in a deep skin crease or beneath a large panniculus, because of the anaerobic environment in this location and increased risk of wound complications. The fascia is incised transversely, and the aponeurosis is not detached from the underlying muscle.

Once the transverse fascia incision has been carried lateral to the borders of the rectus muscles, the inferior epigastric vessels, lying on the posterolateral border of each muscle, are identified in anticipation of ligation; some surgeons suggest preservation of these vessels even when the rectus muscles are transected. The vessels are “teased” away from their attachments by using blunt dissection with an instrument or gentle finger dissection and cleared of fat surrounding the vessels. The vessels are ligated (can be clamped, divided, and each end tied with 2-0 suture) before incising the rectus muscles to avoid tearing of the vessels, vessel retraction, and hematoma formation. The fingers of the surgeon tease the overlying rectus muscle from the peritoneum, and the muscles are sectioned between the fingers by using an electrocautery. Slow intent cautery should be considered to maximize hemostatic division of muscles (**FIG. 8.6**).

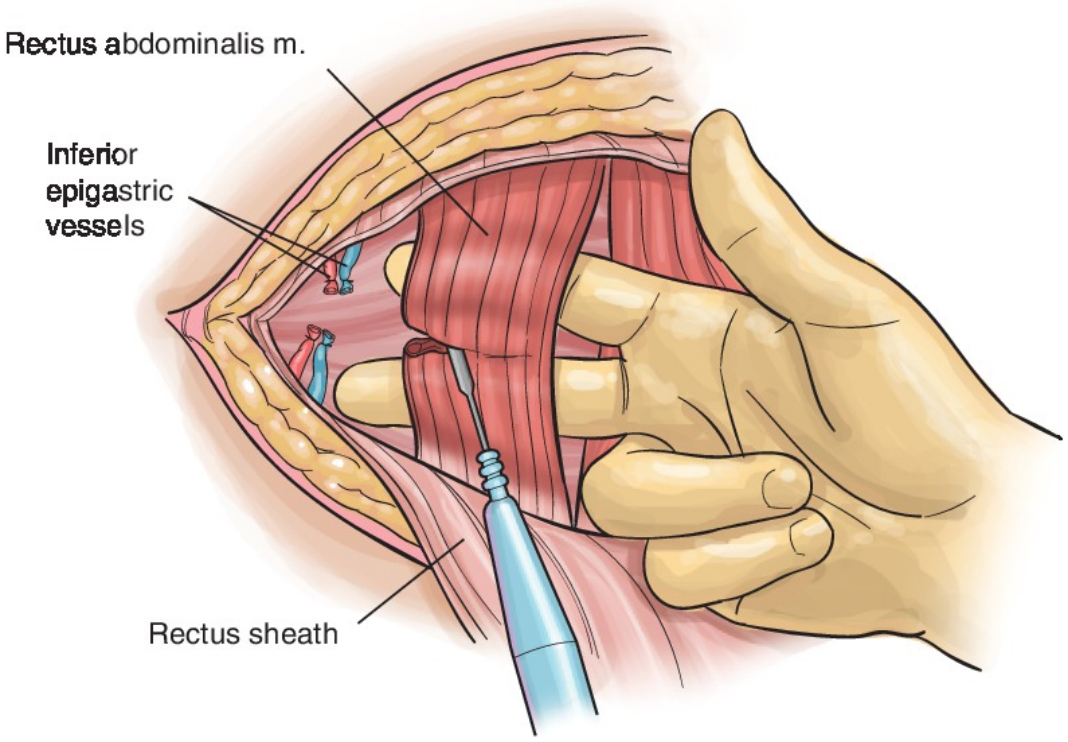



**FIGURE 8.6** Maylard incision. The rectus muscles are incised with a knife or a Bovie device. The hand of the surgeon is withdrawn as the muscle is cut. The inferior epigastric vessels were previously isolated, ligated, and transected.

For better approximation of the muscles during closure, suture the underlying muscle to the overlying fascia before entering the peritoneum. A 2-0 delayed absorbable “U” suture is used, and the knots are placed anterior to the fascia. The peritoneum is incised transversely.

Closure of the fascia is similar to the running technique for other transverse incisions. The muscles do not need to be reapproximated with individual sutures (exception noted above), although some surgeons prefer to close the parietal peritoneum with a running polyglycolic suture (**FIG. 8.7**).

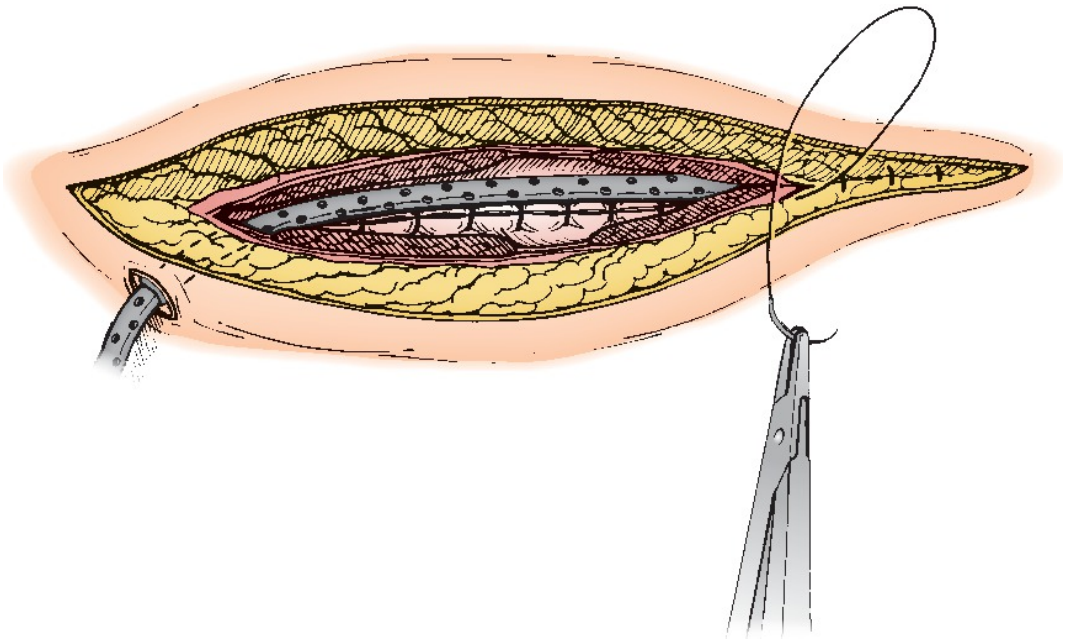


**FIGURE 8.7** Closure Maylard Incision. The peritoneum has been closed with 2-0 polyglycolic acid sutures. A closed drainage system is used if hemostasis is not absolute. A running delayed absorbable suture is used, placing the suture about 1.5 cm from the fascial edge. (Reprinted from Gallup DG. Abdominal incisions and closures. In: Gallup DG, Talledo OE, eds. *Surgical Atlas of Gynecologic Oncology*. 1st ed. WB Saunders; 1994:43. Copyright © 1994 Elsevier, with permission.)

Caution should be exercised in using the Maylard incision in patients with impaired lower extremity circulation secondary to obstruction of the common iliac arteries or terminal aorta. In this situation, blood flow from the inferior epigastric artery may provide the only additional collateral circulation to the lower extremity. Ligation of this artery

could result in lower extremity ischemia and a real vascular surgical emergency. In the gynecologic patient with clinical evidence of impaired circulation in the lower extremity, a midline incision is recommended.

# Vertical Incisions

Generally, vertical incisions afford excellent exposure, can be easily extended, and provide rapid entry to the abdominal cavity. Whether the incision is made midline or paramedian, the resulting scar may be wide.

## *Midline (Median) Incision*

The midline incision is the least hemorrhagic incision, as well as the incision that affords rapid entry into the abdominal/pelvic cavity. Exposure is excellent, and minimal nerve damage occurs. However, dehiscence and hernia are more common. The midline incision is the most easily mastered gynecologic incision because the fascial area is relatively bloodless, and the rectus muscles are usually separated in parous women. If the patient has a prior midline incision, the surgeon should incise the skin and peritoneum more cephalad to the earlier incision to avoid injury to possibly adherent bowel. In nulliparous women, the midline separation between the rectus muscles may not be obvious. In these cases, the pyramidalis muscles are useful landmarks in directing the surgeon to the midline separation of the rectus muscles, inferiorly. Because this incision can be extended easily, the midline incision is the most versatile of all incisions used by gynecologists (**FIG. 8.8A-D**).

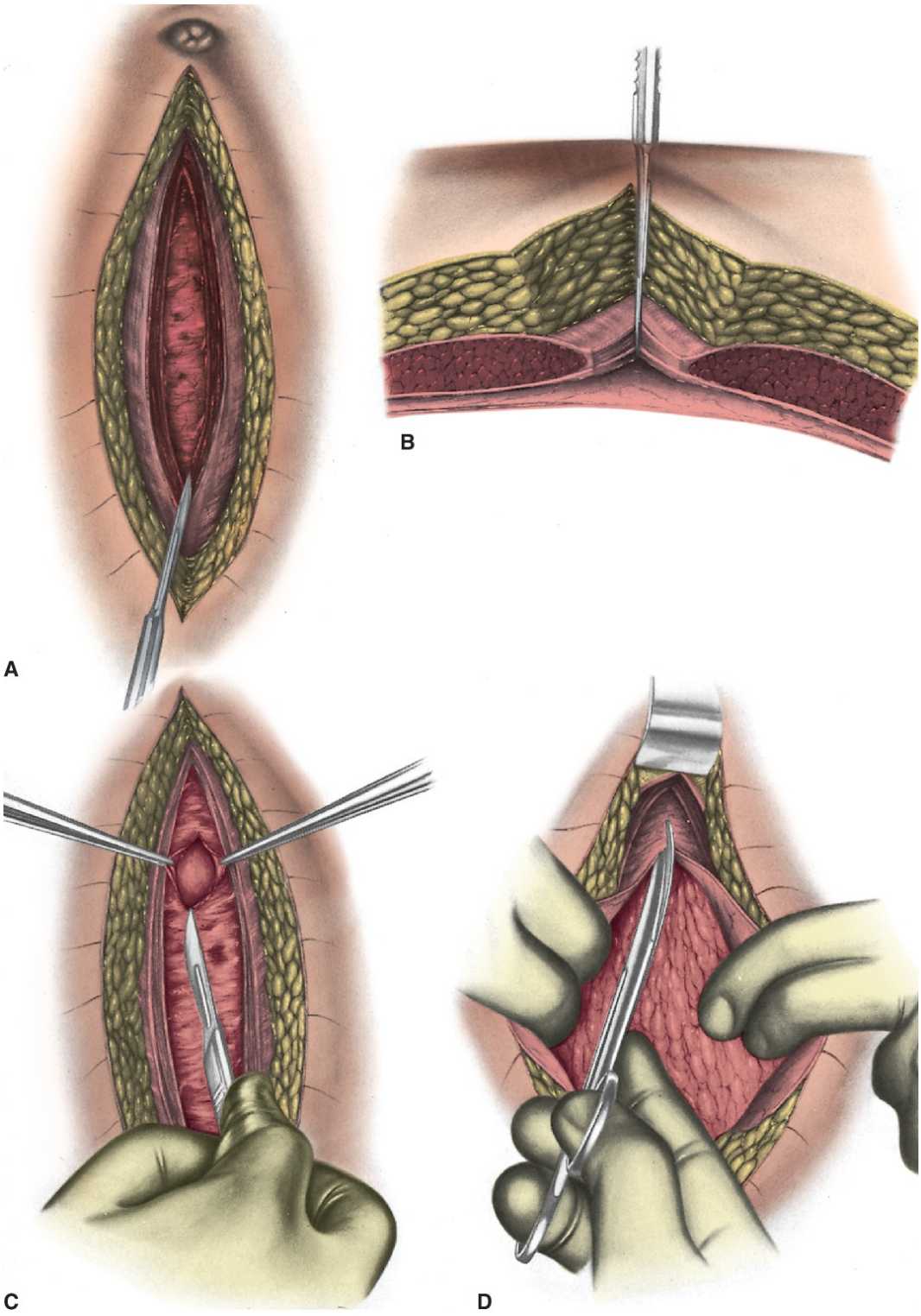



**FIGURE 8.8** Midline Incision. **A.** Cutting of linea alba in low midline incision with scalpel.

**B.** Cross section of abdominal wall showing the skin, subcutaneous fat, anterior and posterior rectus sheaths, and underlying peritoneum. **C.** Opening of peritoneum with knife and demonstration of small bowel protruding into peritoneal opening. **D.** Enlargement of peritoneal opening to the region of the umbilicus with Mayo scissors.

Hemostasis of the anterior layers of the abdomen should always be complete before the peritoneum is entered. Once the abdomen is explored in a systematic fashion, the bowel is carefully packed out of the pelvis. Seldom are more than two or three moist laparotomy packs needed to accomplish exposure of the pelvis. If more packs are required or there is a struggle to pack the upper abdominal contents, anesthesia may be inadequate, or in patients with prior abdominal surgery, adhesive disease may be obstructing movement. The more packs used, the more likely small bowel terminal nerve endings will be damaged, resulting in postoperative adynamic ileus. Use of more modern table-fixed retractors, such as the Bookwalter retractor, improves exposure in vertical and transverse incisions and limits the need for use of excessive packs.

## *Paramedian Incision*

The true paramedian incision is placed lateral to the midline and splits the rectus muscle longitudinally. Similar to the midline or median incision, the paramedian incision has excellent extensibility and exposure, particularly on the side of the pelvis where the incision is made. However, because it splits the rectus muscle, the risk of bleeding and nerve injury is increased, relative to the median incision. A modified paramedian incision retracts the rectus muscle laterally before incising the posterior rectus sheath and peritoneum. This approach avoids the potential risks associated with splitting the

rectus muscle. Paramedian incisions have been advocated over midline incisions because of alleged greater strength. A recent meta-analysis by Bickenbach et al. comparing outcomes of midline incisions with transverse and paramedian incisions showed that midline incisions had higher hernia rates as compared to transverse incisions (risk ratio [RR] 1.77, 95% confidence interval [CI]: 1.09-2.87) and paramedian incisions (RR 3.41, 95% CI: 1.02-11.45).

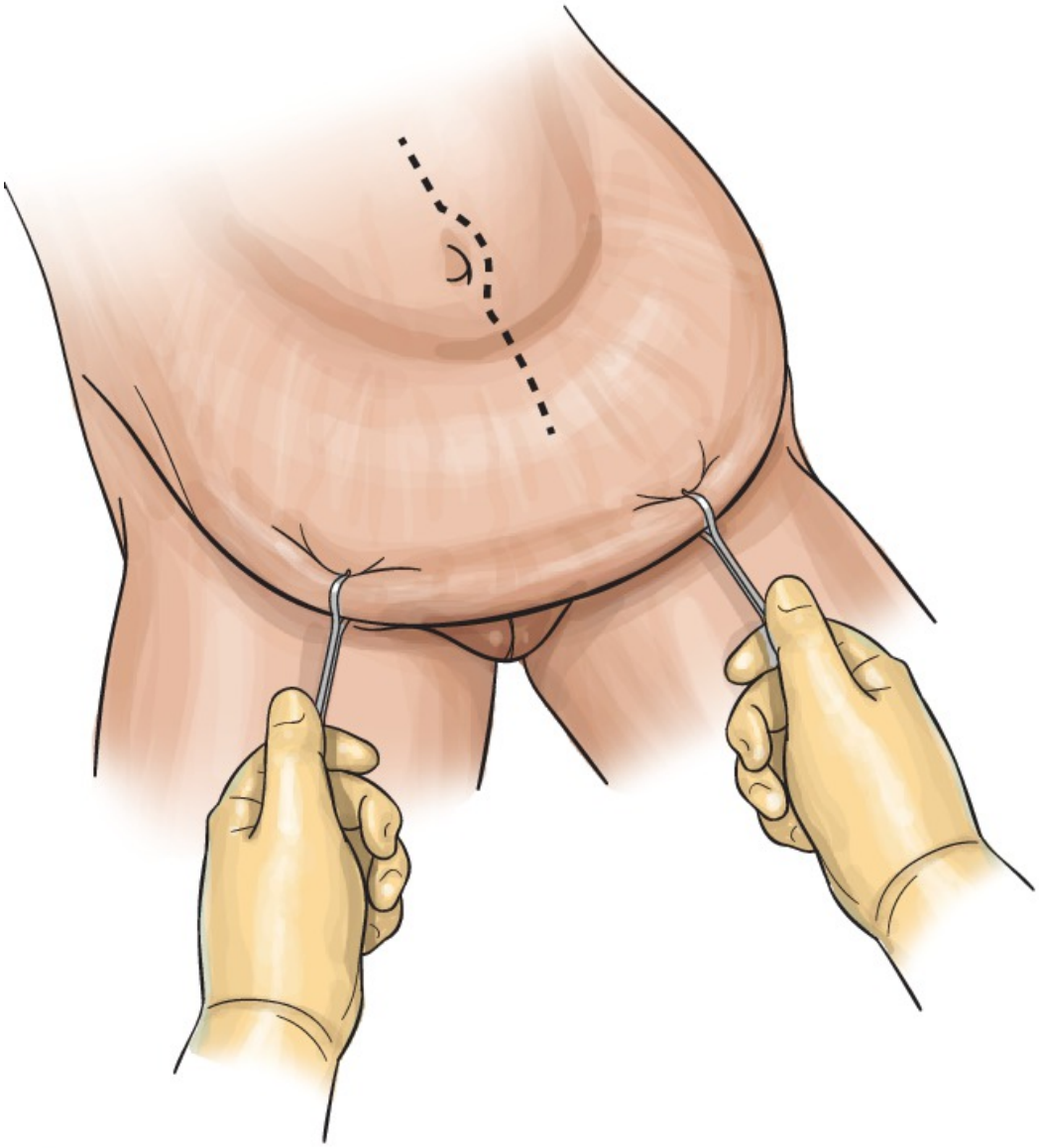
# INCISIONS FOR OBESE PATIENTS

Obesity is epidemic in the United States. In 2017–2018, the age-adjusted prevalence of obesity (body mass index [BMI] ≥ 30 kg/m$^2$) in adults in the United States was 42.4%, and there were no significant differences between men and women among all adults or by age group. The age-adjusted prevalence of severe obesity (BMI ≥ 40 kg/m$^2$) in adults was 9.2% and was higher in women than in men during the same time. Obesity is a recognized risk factor for SSI, with rates as high as 12% among patients who are severely obese. Retrospective studies have shown that patients with severe obesity have a 10 times greater risk of wound complications (including SSI) when compared to patients with normal weight. Thus, placement of abdominal incisions in these patients can be challenging.

## Midline Incision for the Obese Patient

If a midline incision is chosen for the obese patient, it is recommended that the umbilicus is retracted caudally on a vertical axis in the supine and dorsal lithotomy positions to or below the level of the pubic symphysis, depending upon the size of the panniculus. The skin incision is a periumbilical incision because it is usually extended around the umbilicus and more cephalad due to the caudally deviated position of the umbilicus. The fascial incision is always extended to the symphysis. A supraumbilical longitudinal incision, as described by Greer and Gal, is a variation, where the entire incision is above the umbilicus, in the flat area of the abdomen above the panniculus. Several other options for incisions on the

obese abdomen exist. Querleu described a transverse incision, similar to the Maylard incision described above (**FIG. 8.9**).



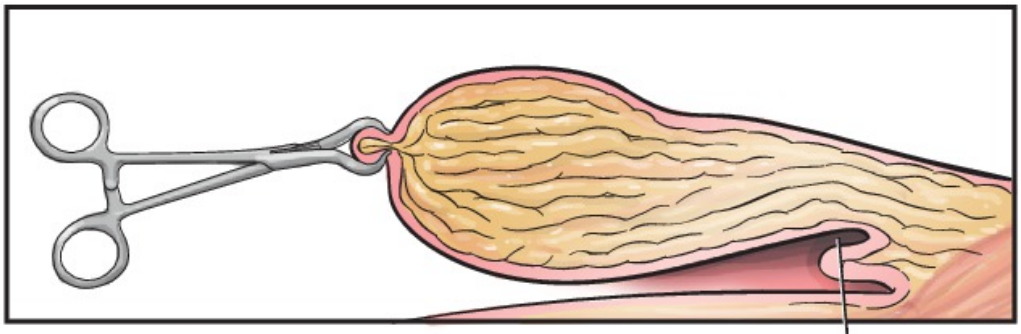

Anaerobic
area

**FIGURE 8.9** Midline incision in an obese patient. The panniculus is retracted inferiorly, and the incision avoids the moist anaerobic environment **inset** beneath the subpannicular fold.

After the operation is completed, the abdominal fascia is closed with a monofilament, slowly absorbing (or occasionally monofilament nonabsorbable) suture such as polydioxanone suture (PDS) in a continuous mass closure. Subcutaneous sutures and/or drains are not used. The skin is closed with staples, which are left in place for 2 weeks.

## Panniculectomy and Abdominoplasty

Although these procedures have been espoused as an supplemental surgical approach in combination with gynecologic surgery in the massively obese patient, the combination of the two procedures has recently been called into question. Several retrospective series, reported from single institutions, noted the relative safety of combining abdominoplasty with gynecologic surgeries (mostly oncologic surgical interventions). However, claims of reduction of depth, better exposure, and better control of abdominal viscera represented opinion of the authors due to the lack of a comparator group to make such beneficial claims. A recent analysis of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) found no benefit in combining panniculectomy, abdominoplasty, or gynecologic surgeries in obese patients (BMI > 30). In fact, the analysis demonstrated increased morbidity for these patients. The authors found 296 patients who had concomitant panniculectomy with gynecologic surgery in the NSQIP cohort (out of almost 47 000 gynecologic surgeries [0.63%]). Their analysis showed higher rates of superficial infections (10.5% vs 4.5%; $P$ = .001), wound infections (2.4% vs 0.54%; $P$ = .0014), pulmonary emboli (2.4% vs 0.85%; $P$ = .147), systemic sepsis (4.7%

vs 1.6%; *P* = .0004), longer operative times (259.96 minutes vs 158.32 minutes; *P* ≤ .0001), and greater lengths of hospital stays (5.1 days vs 3.92 days; *P* ≤ .0001) when compared to patients having gynecologic surgeries alone. When the patients were further categorized into BMI > 35 and >40, the significance of the above-mentioned metrics was more glaring, as it was noted that morbidly obese patients with BMI > 40 had even greater rates of blood transfusions (19.5% vs 12.7%; *P* = .0332). The authors concluded that there is a lack of evidence to support combining these procedures. Given these recent data, panniculectomy and abdominoplasty combined with gynecologic surgery should be avoided unless there are mitigating reasons to combine the procedures. Patients should be counseled and strongly motivated to lose weight by changes of nutritional and exercise habits. If the surgical procedure is not urgent, an alternative would be to defer the procedure until the patient has achieved 40%-50% of the planned weight loss (**FIG. 8.10A-F**).

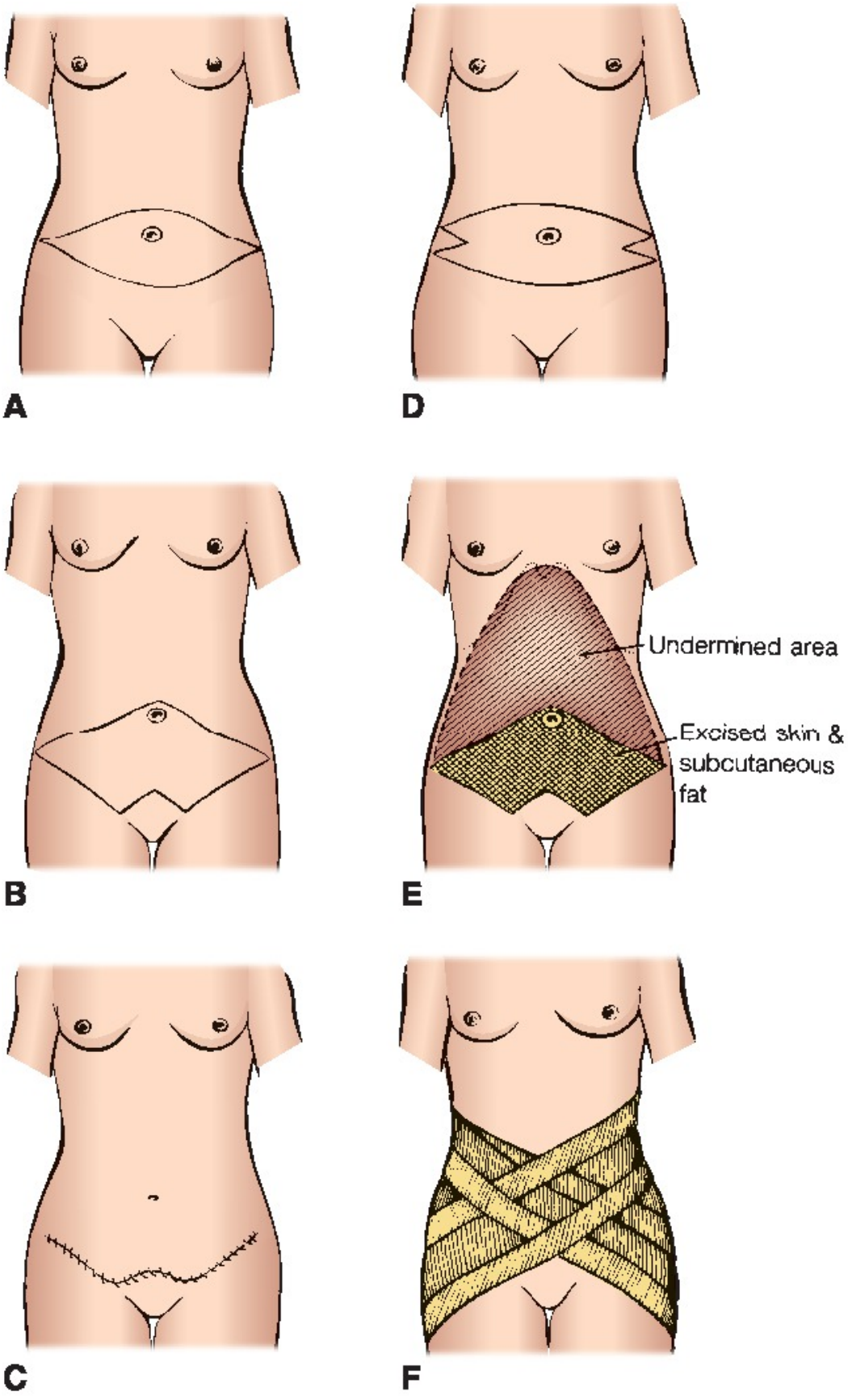

A
D
B
E
Undermined area
Excised skin & subcutaneous fat
C
F

**FIGURE 8.10** Panniculectomy incisions. **A.** Elliptical transverse incision extending from the region of iliac crest passes above and below the umbilicus. **B.** V-shaped incision in lateral angles eliminates folds of skin in abdominal wall. **C.** W-shaped incision over the mons pubis extends along the inguinal ligament to the iliac crest. **D.** The upper incision passes above the umbilicus. Wide mobilization of the upper skin flap is carried to the sternum and rib margins. **E.** After removal of panniculus and skin, the upper skin flap is sutured without tension to the lower skin margin. **F.** A firm elastic dressing is crisscrossed over the abdominal wall for abdominal support and prevention of seroma formation.

## PERINEOTOMY INCISIONS

Adequate exposure is just as important with vaginal surgery as it is with abdominal surgery. When exposure is not adequate with abdominal operations, the incision is extended, or some other measure is used to improve exposure. Certain measures also can improve exposure with vaginal operations. A narrow vaginal introitus may restrict exposure of the upper vagina but can be enlarged at the beginning of the operation by making a midline or mediolateral episiotomy incision. A mediolateral incision can be made on one or both sides of the vaginal introitus. If a midline episiotomy is made

and closed transversely, the vaginal introitus can be made larger than before, if that is deemed advisable. These incisions can be closed with 2-0 or 3-0 delayed absorbable suture.

Sometimes, the entire vagina is small in caliber because of lack of sexual activity or nulliparity, atrophic vaginal mucosa, previous colporrhaphy, or previous irradiation of malignant disease. The vaginal vault may be fixed in a relatively high position, with relatively little descensus. Because adequate exposure through the vagina may be impossible, some operations may require an abdominal approach. On the other hand, improved vaginal exposure may be obtained by making a Schuchardt incision. The entire vagina can be enlarged with this incision, achieving remarkable improvement in exposure of the upper vagina. Therefore, a patient whose problem might otherwise have necessitated an abdominal approach can have the advantage of a perfectly satisfactory vaginal operation if a Schuchardt incision is made.

According to Speert (1958), Langenbeck made a deep relaxing incision into the perineal body in attempting vaginal hysterectomy for uterine cancer in 1828. Similar incisions were used by Olshausen in 1881 and Duhrssen in 1891. Karl Schuchardt described his incision in 1893:

> *to make more accessible from below a uterus whose mobility is limited…. With the patient in the lithotomy position and her buttocks elevated, a large, essentially sagittal incision is made, somewhat convex externally, beginning between the middle and posterior third of the labium majus, …extending posterior toward the sacrum, and stopping two fingerbreadths [sic] from the anus. The wound is deepened only in the fatty tissue of the ischiorectal fossa, leaving the funnel of the levator ani muscle, the rectum behind it, and the sacral ligaments intact. Internally, the sidewall of the vagina is opened into the ischiorectal fossa, and the vagina is divided in its lateral aspect by a long incision extending up to the cervix. There thus results a surprisingly free view of all the structures under consideration.*

# Schuchardt Incision

The incision is ordinarily made on the patient's left side by a right-handed operator. A left-handed operator may find it technically easier to make the incision on the patient's right side. Bilateral incisions have been advocated in extreme cases. The side on which the incision is made may be dictated by the location of the pathology to be removed. Injection of the tissues to be incised with sterile saline solution can be helpful, especially beneath the vaginal mucosa in the line of the incision. The assistant pulls upward to the left with the index finger placed as deep as possible in the vagina just to the left of the urethra. The operator places countertraction by pressing two fingers in the vagina and pulling downward to the right. This pull and counterpull in opposite directions stretches the left vaginal wall. The incision is made with the electrosurgical unit beginning at the 4 o'clock position at the introitus and extending downward in the skin of the buttock to the level of the anus. The incision is then carried upward through the vaginal mucosa into the upper third of the vagina. As the incision is deepened, the fingers of the operator's left hand are used to displace the rectum medially to protect it from injury. The ischiorectal fossa fat is visible below the puborectalis muscle, which is incised with the electrosurgical knife. If necessary, the left paravesical space can be developed. For the best possible exposure, the apex of the vaginal incision should intersect any incision made around the cervix, achieving hemostasis by coagulation or ligation.

At the end of the operation, the Schuchardt incision is closed with 2-0 and 3-0 delayed absorbable sutures, attempting to reapproximate the puborectalis muscle edges and to obliterate the dead space in the ischiorectal fossa. Drainage of these incisions is usually not necessary.

The Schuchardt incision is used for extensive vaginal hysterectomy for early invasive cervical cancer. We also have used it when performing extensive dissections to remove endometriosis in the vaginal vault, to gain better exposure for difficult vaginal hysterectomy or vesicovaginal fistula repair, to repair injuries to the lower ureter, to remove organized hematomas just above the

puborectalis muscle, to drain lymphocysts vaginally, or to remove benign cystic teratomas in the lower presacral area behind the rectum. It can convert a technically difficult, complicated, and dangerous vaginal operation into one that is simple, easy, and safe. It is difficult to understand why perineotomy incisions are so quickly performed for obstetric operations and so reluctantly for gynecologic operations (**FIG. 8.11A, B**).

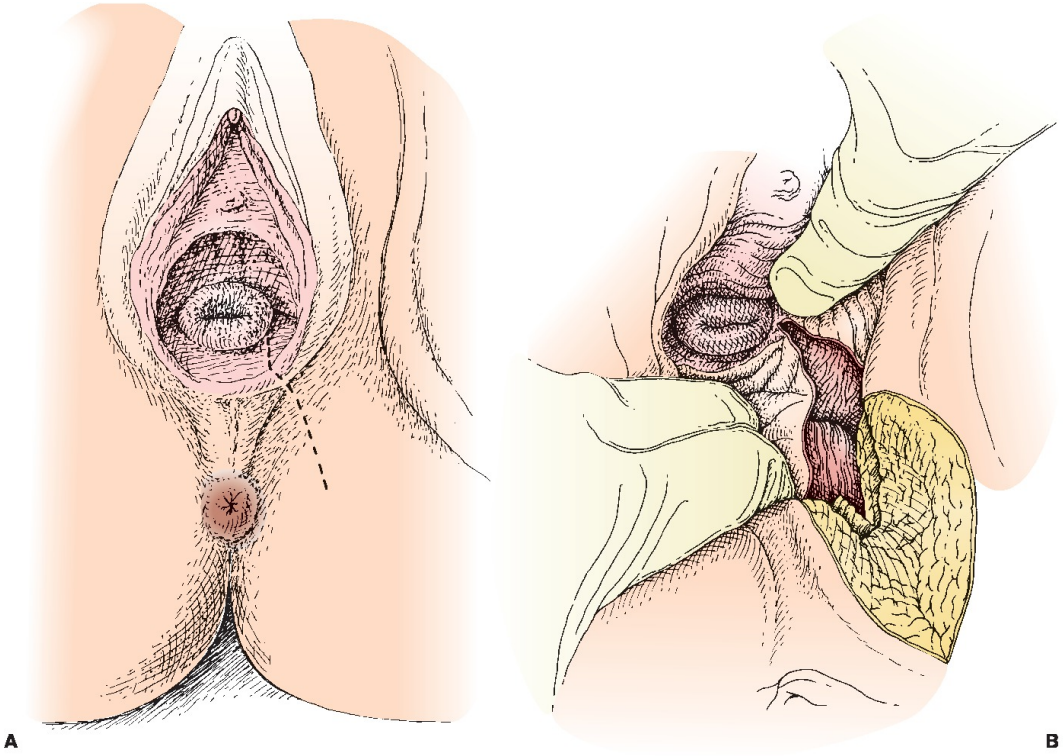



**FIGURE 8.11 A.** The Schuchardt incision begins at the 4 o'clock position in the vaginal introitus and extends into the buttock and up the posterolateral wall of the vagina to the cervix. **B.** The ischiorectal fossa fat is exposed. The puborectalis muscle is divided. The left paravesical and pararectal spaces can be exposed through the incision.

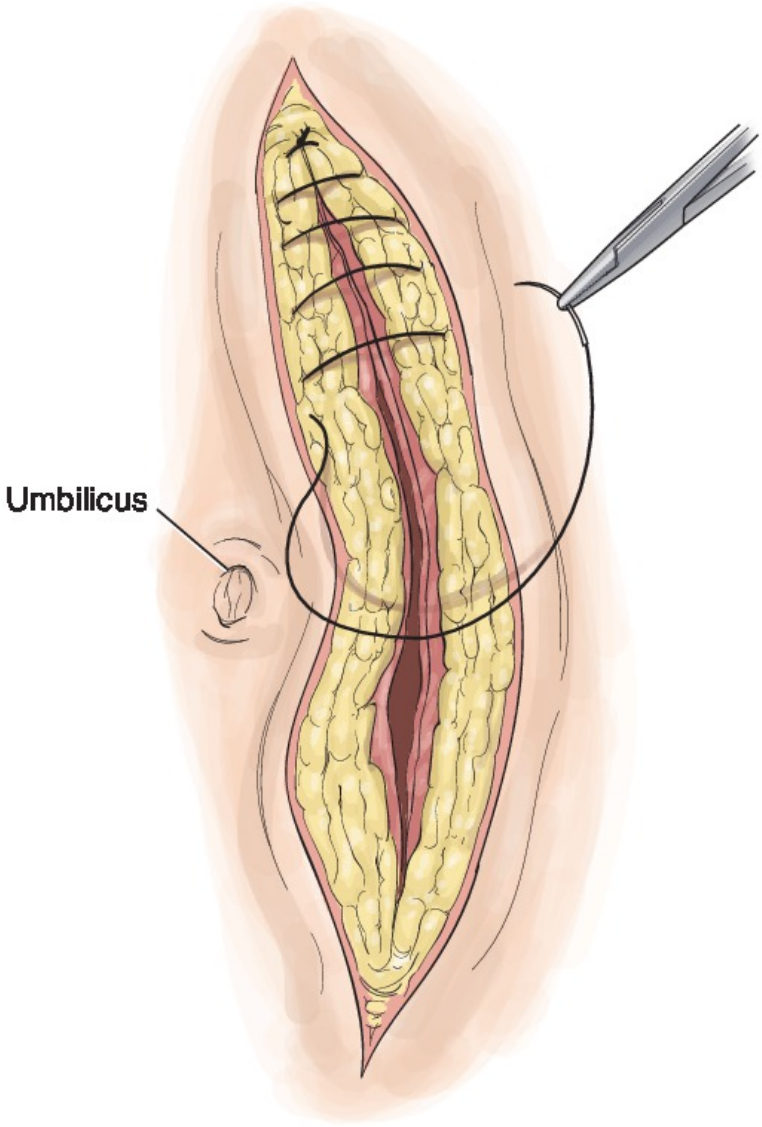
# CLOSURE OF VERTICAL INCISIONS

Although midline incisions allow quick entry into the abdomen and provide excellent exposure to abdominal and pelvic anatomy, the relatively avascular nature of the anatomy, as well as the lateral pulling forces, make these types of incisions weaker and prone to early and late postoperative complications. Incisional hernia (IH) is a frequent late complication of midline abdominal surgery with a reported incidence of 10%-23% (up to 38% in some high-risk groups) and typically results in some future surgical intervention, increasing patient morbidity and decreasing patient quality of life. Most IHs develop during the early postoperative period and are related to early separation of the fascial edges. Because the regenerative capability of fascia is limited, the ability of the closing suture line to hold these edges together during the early postoperative period is paramount. The fascia heals quite slowly and needs suture support for complete healing for at least 6 weeks to reduce the risk of IH formation. The surgeon can control several variables (eg, reducing surgical site infections, choosing an appropriate suture for closure, employing proper suturing technique, etc.) to reduce the rate of hernia formation.

Selecting a suture to close midline abdominal incisions is the prerogative of the surgeon; although a myriad of options exists, there is no consensus on the choice of suture material or even closure technique. Over the last two decades, multiple prospective randomized clinical trials have been completed comparing one suture to another and evaluating for wound complications, such as hernia formation, wound infection, suture sinus formation, wound pain, and dehiscence. Although some classes of suture outperformed others, to date, no single suture has emerged as the sole superior choice for closure of midline incisions. As previously discussed, one of the most important factors of closure of the midline incision is that the fascial edges need to be approximated for at least 6 weeks to reduce hernia formation. Nonabsorbable monofilament and slowly absorbable (eg, PDS) suture material produce low rates of IH, as compared to fast-absorbing suture, which support the fascia for <6 weeks.

The rate of surgical site infections (SSIs), a postoperative infection occurring at the surgical site, may be lower with monofilament suture compared to multifilament material, owing to the interstitial spaces where bacteria can evade phagocytosis. Diener et al. performed a meta-analysis of midline laparotomy closures and found that hernia rates were significantly lower with absorbable suture vs nonabsorbable suture (odds ratio 0.41, 95% CI: 0.43-0.82, *P* = .001) and slowly absorbable vs quickly absorbable sutures (odds ratio 0.65, 95% CI: 0.19-0.88, *P* = .02). No statistical differences were noted among the secondary end points of wound dehiscence, suture sinus formation, wound infection, and wound pain, whether wounds were closed with nonabsorbable vs slowly absorbable or slowly absorbable vs quickly absorbable suture material. The authors concluded that for elective primary or secondary laparotomy through midline incisions, the abdominal fascia should be closed with slowly absorbable (monofilament) suture material in a continuous fashion. The authors had no recommendation for closure of the abdominal fascia in emergency setting. A recent Cochrane review concluded that suture absorption (absorbable vs nonabsorbable and slow vs fast absorption), closure method (mass closure vs layered), or closure technique (continuous vs interrupted) did not result in any difference in hernia rate. There was no difference in wound infection or wound dehiscence by suture absorption, closure method, or closure technique.

Good suturing technique is as important as choosing the best suture material for midline laparotomy closures. Although the evidence shows that no one superior suture material or technique is associated with reduced IH formation, the continuous closure technique is significantly easier, is faster to complete, and is preferred when compared to interrupted closure (**FIG. 8.12**).


Umbilicus

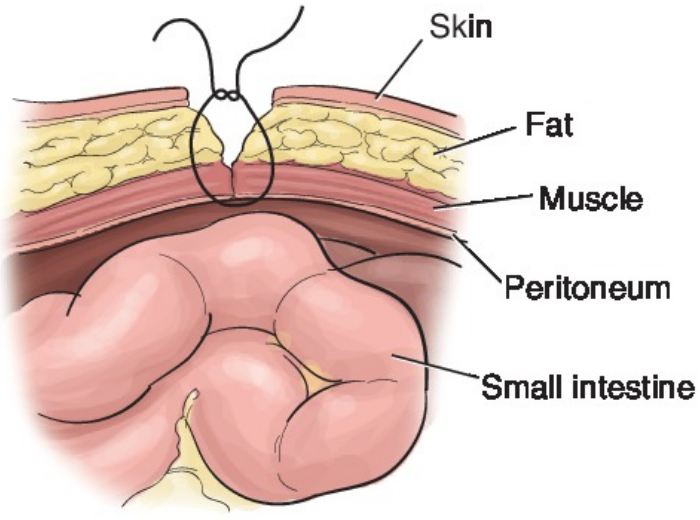

Skin
Fat
Muscle
Peritoneum
Small intestine

**FIGURE 8.12** Closure of a midline incision using a running mass closure. The anterior fascia, muscle, posterior fascia, and peritoneum are included in the bites (inset), which are taken 5-8 mm from the fascial edge and about 5-8 mm apart ("small bites").

Standardizing the tension applied on sutures in the clinical setting during closure of the abdomen is difficult. However, higher tension is correlated with higher rates of SSI than with lower tension; soft tissue that is included in a high-tension stitch may be compressed and devitalized, leading to tissue necrosis and SSI. For continuous closure, the *suture length-to-wound length* (SL-to-WL) ratio is directly correlated with IH formation (fewer hernias with SL-to-WL ratio of 4 or higher) but depends upon the number of stitches, the size of the stitches, the tension on the suture line, and the length of the wound.

$$\text{Calculation of SL - to - WL ratio: } \left(A - [B + C]\right) / D$$

*A* = length of suture used

*B* = length of suture remnants at the starting knot

*C* = length of suture remnants at the finishing knot

*D* = length of skin incision

High SL-to-WL ratio can be accomplished with large stitches ("large bites") or with small stitches ("small bites") (**FIG. 8.13**) placed at closer intervals. For several decades, it had been recommended to place large stitches at least 1-1.5 cm from the fascial edge and 1 cm apart. This surgical dictum was purely based upon experimental data. However, recent experimental data from Cengiz et al. showed that smaller stitches, placed 5-8 mm from the wound edge and at

close intervals of 4-5 mm, resulted in a stronger wound 4 days after closure compared to wounds closed with larger stitches, placed 10 mm from the edge and 10-15 mm apart.

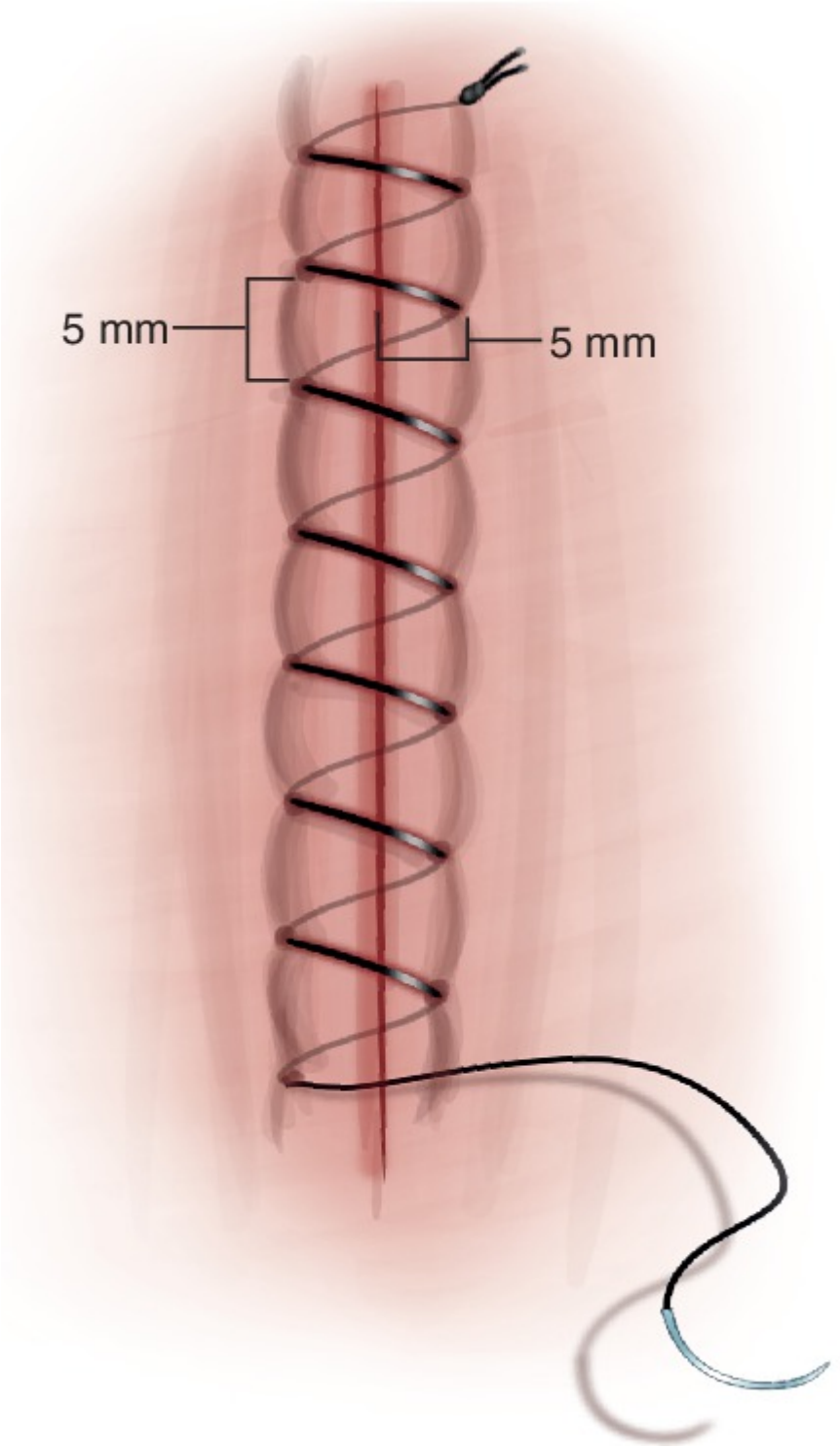


**FIGURE 8.13** Small stitches or small bites to obtain a suture to wound length (SL:WL) ratio of at least 4:1 to close a midline abdominal incision.

The interrupted Smead-Jones closure technique (**FIG. 8.14**) has not been shown to be superior to a continuous closure technique in patients at high risk for wound disruption. This technique is a far-far, near-near, interrupted, mass closure technique. The first (far-far) bite includes both the fascia and peritoneum on each side, and only the anterior fascia is included in the near-near bite. The widely spaced initial pass takes the tension off the healing incision, while the carefully placed near-near bites approximate the fascial edges. A nonabsorbable or slowly absorbable suture is used, with the key to the success of this closure being widely spaced far-far bites (at least 1.5-2 cm from the fascial edges) (**BOX 8.1**).

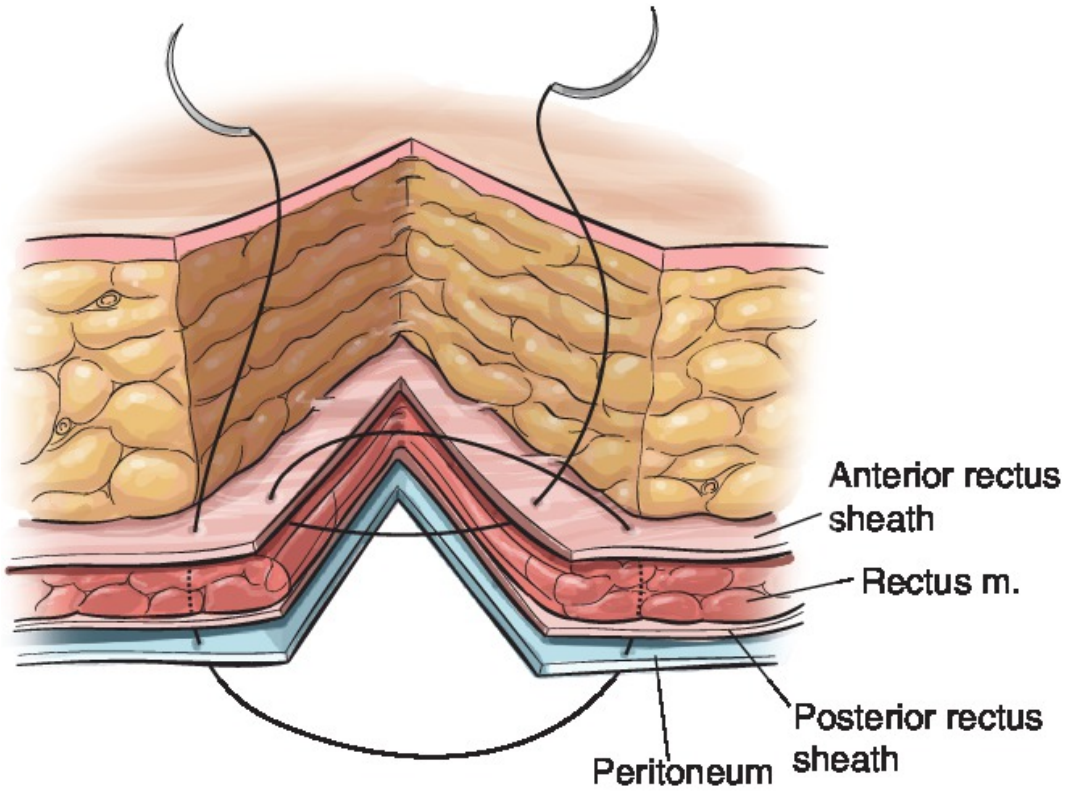


**FIGURE 8.14** Smead-Jones layered closure. This is a far-far, near-near suturing technique, with the anterior fascia being included in the near-near bite. A no. 1 nylon or no. 1 polypropylene suture (or some other delayed absorbable suture) is used, with the key to the success of this closure being widely spaced far-far bites (at least 1.5-2 cm from the fascial edges). This closure technique may be performed in an interrupted fashion or as running suture.

## BOX 8.1 STEPS IN THE PROCEDURE

### Recommendations for Wound Closure

- Use a monofilament suture material, slowly absorbable.
- Use a continuous suture technique.
- Close the wound in one layer.
- Avoid high tension on the suture—adapt but do not compress the fascia edges.
- Place the stitches in the fascia only, 5-8 mm from the wound edge and at close intervals 5-8 mm apart.
- The SL-to-WL ratio should be 4 or greater.

# Use of Drains

Drainage of the abdominal cavity is appropriate after an operation for a tuboovarian abscess or other type of pelvic infection. In addition, intraperitoneal drainage may be helpful for oozing peritoneal

surfaces after complicated hysterectomies or other pelvic surgery. Although used in the past for prevention of lymphoceles or ureteral fistulae, retroperitoneal drains are not routinely used after radical pelvic surgery.

The use of prophylactic drains in the subcutaneous space to reduce the formation of hematoma and seroma or to reduce abscess and infection remains controversial. A large meta-analysis of the subject was reported, showing that subcutaneous drains could be omitted after cesarean section, breast reduction surgeries, abdominal surgeries (clean-contaminated wounds), femoral wounds, and hip and knee joint replacement. Drain placement is not recommended solely due to patient obesity. Farnell and associates, in a prospective study, analyzed 3282 incisions of various types. When patients with clean-contaminated or contaminated wounds underwent placement of subcutaneous closed drainage systems, alone or with antibiotics or saline irrigation, no significant advantage was noted compared with primary closure without drainage. However, a trend favoring subcutaneous drainage and antibiotic irrigation was seen in patients with contaminated wounds.

Drains can be classified into two categories: passive and active. The passive drain functions primarily as an overflow “valve” being assisted by gravity, while the latter drain is connected to some type of suction device. If a drain is used at all, the preferred system is a closed drainage system such as a Jackson-Pratt or a Blake. Both have small reservoirs (100 mL) that are easily manged on the ward and at home. The Blake drain, with its longitudinal ridges, offers less chance of obstruction from small tissue fragments or clots than does the Jackson-Pratt drain. However, no large prospective, randomized trials comparing these two systems have been done to substantiate that claim. To avoid clot formation and subsequent obstruction, the drain is placed on suction early, usually while completing closure of the incision. In addition, the nursing staff (and other caregivers) should be instructed to “strip” the drain catheter each shift (or several times throughout the day) while the drain is in place. Drains in the subfascial or subcutaneous spaces should be removed and not advanced. Once the drainage is <50 mL/24 hours, usually by postoperative day 2 or 3, it can be safely removed.

# Delayed Primary and Secondary Closure

Most incisions for gynecological surgery heal by primary intention, that is, the incision/wound is closed by fixing the edges together with sutures, staples, adhesive glue, or clips. However, some wounds will be left open to heal when there is a high risk of infection or when there has been significant loss of soft tissue. Healing for these wounds occurs through growth of new tissue upward from the base of the incision, in a process called healing by secondary intention. Sometimes wounds that are closed by primary intention will dehisce due to superficial SSIs, hematomas, or seromas and result in partial or full separation of wound edges. After draining abscesses, hematomas, or seromas, these wounds are usually left open to heal by secondary intention or are closed by delayed secondary closure. The value of delayed primary wound closure in managing possibly contaminated wounds was originally recognized by military surgeons and more recently by trauma surgeons to control abdominal sepsis. Similarly, in high-risk patients, including obese patients, cancer patients, and patients with contamination from “above-and-below” procedures, infection, or bowel contents, there was a marked reduction in wound infection rates when delayed primary closure was used compared with immediate closure in matched patients. The infection rate for the former group was 2.1% and for the latter, 23.3%.

One method of delayed closure utilizes wet-to-dry dressing changes. After closure of the fascia, a nonabsorbable suture can be placed every 2 cm, in a vertical mattress fashion (far-far; near-near), but not tied down. The wound is then irrigated with copious amounts of saline and then packed with 0.25% Dakin solution (sodium hypochlorite) between the sutures. The wound dressing sponges are changed twice daily with a wet-to-dry technique, using sterile saline or 0.25% Dakin solution. Once the signs of infection have resolved, the Dakin solution should be stopped, as it can impede epithelialization. In 4-5 days, depending on the appearance of granulation tissue in the subcutaneous tissues, the previously placed

sutures are tied to approximate the skin edges. Tincture of benzoin is placed at the lateral edges of the closed incision, and Steri-Strips are used to approximate uneven skin edges.

Alternatively, the skin edges of the incision can be closed with widely spaced staples, “wicking” the intervening spaces with saline-soaked (Dakin solution in the face of infection) gauze (eg, Nu Gauze or Kerlix strips). Once adequate granulation tissue is present, the skin edges can be reapproximated with nonabsorbable monofilament sutures after infiltration with local lidocaine at the patient’s bedside before discharge from the hospital.

After primary closure of the wound and several days after the operation, some patients will develop a hematoma, a seroma, or a superficial wound infection that will necessitate opening the wound by removal of staples or cutting out the subcuticular suture. More times than not, the wound will need to be opened in its entirety to allow adequate drainage and to potentially débride any necrotic tissue present. Bacterial cultures are obtained to assist in selection of antibiotics. The wound is left open to allow healing by secondary intention, with once- or twice-daily wound dressing changes with either saline or Dakin’s-soaked gauze sponges. Although most cleansing of the wound healing by secondary intention is accomplished by home health care personnel, patients are inconvenienced by this method of healing. A trend in many centers has been to perform delayed closure after a period of 2-5 days.

In a larger series of patients on an obstetrics and gynecology service, Walters and colleagues found a similar advantage in delayed closure of wounds. Thirty-five patients in this study had abdominal incisions that had been opened due to infection, hematoma, or seroma. The fascia was intact in all patients, and all patients had wound débridement and cleansing for a minimum period of 4 days. All patients in this series had re-closure performed in the operating room and received three doses of cefazolin antibiotic. The closure was performed using an *en bloc* technique, with placement of no. 2 monofilament nylon sutures, and 85.7% of wounds were successfully closed. However, an *en bloc* closure required longer time for closure, and patients experienced more pain.

# Negative Pressure Wound Therapy

Rather than leaving the incision open to heal by secondary intention for high-risk patients, negative pressure wound therapy (NPWT) is recommended. This device can be employed in an open wound (open NPWT) (**FIG. 8.15**) or by placing a device on the wound following primary skin closure (closed NPWT or incisional NPWT). Since the first reports of this type of therapy for chronic wounds in 1997, NPWT has revolutionized the wound healing world, because of its ability to speed wound healing and approximation.

**FIGURE 8.15** Open system negative pressure wound therapy.

## *Open Negative Pressure Wound Therapy*

For open NPWT, a black polyurethane foam or white polyvinyl alcohol foam is cut to conform to the wound, sealed, and connected to tubing that is connected to a pump that produces subatmospheric pressures (50-125 mm Hg). The mode of the pump is either

intermittent or continuous. The mechanism of action is that the foam occludes the wound, allowing for quicker epithelialization, and drains away any exudates. In addition, the subatmospheric pressure creates tissue strain, stimulating cellular proliferation, angiogenesis, and growth factor elaboration. Inflammation and edema are reduced, with all the associated mediators, and the bacterial load in the wound is reduced. The black foam, which has the larger pores, is considered most effective at stimulating wound contraction and formation of granulation tissue. The white foam has a smaller pore size and is utilized to restrict granulation tissue growth. Contraindications to NPWT include exposed vessels, anastomotic sites, organs, nerves, malignancy, untreated osteomyelitis, nonenteric and unexplored fistulae, and necrotic tissue. The presence of necrotic tissue requires aggressive débridement prior to placement of NPWT. This type of wound therapy can be used immediately in the operating room after the closure of fascia or as a method to reclose a wound opened due to superficial SSI, hematoma, or seroma formation.

A recent multicenter randomized controlled trial demonstrated that the use of open NWPT significantly shortened the number of days for wound closure vs conventional wound therapy (36.1 days vs 39.1 days; 95% CI: 1.6-4.4; $p < .001$) although the risk for wound-related adverse events was higher in the open NPWT arm (RR 1.51; 95% CI: 0.99-2.35). Similarly, a meta-analysis showed shorter times to wound healing, better wound healing rates, and shorter hospital stays.

## *Closed Negative Pressure Wound Therapy*

Surgical site infections cause significant morbidity and mortality, are associated with an increased risk of wound and fascial dehiscence, reoperation, unplanned readmissions, and extended length of stay. In addition, the harmful effects on patients' quality of life cannot be understated and the economic burden is significant. In the last several decades, measures to help reduce SSIs have been studied, including a focused on wound management with the application of

closed NPWT. Although the mechanism of action is not completely understood, closed NPWT is thought to increase blood flow to the incision, decrease lateral and shear stress to the suture lines, possibly leading to a decreased risk of wound dehiscence, and increase lymph fluid clearance. In recent years there has been an expanding body of study, showing mixed results of a reduced numbers of SSIs, wound dehiscence rates, hematoma and seroma formation. A recent meta-analysis of 44 randomized trials, across several surgical specialties (9 studies from cesarean sections and gynecological surgeries) showed a 40% reduction of SSI when closed NPWT was used vs conventional wound dressings (RR 0.61, 95% CI: 0.49-74, $I^2$ = 26%). This reduction of SSI held true across all surgical specialties and with all brands of NPWT devices and, as expected, had the greatest benefit for wound classes III/IV (**TABLE 8.3**). The number needed to treat with closed NPWT to prevent 1 additional SSI was 30 and 22, respectively, for wound class III and IV. In addition, there was a decrease in wound dehiscence (RR 0.76, 95% CI: 0.62-0.92, $I^2$ = 0%) and seroma formation (RR 0.64, 95% CI: 0.42-0.98, $I^2$ = 0%), but not hematoma formation. There have been several trials evaluating closed NPWT for wound management in gynecological surgery, but only one trial was an randomized trial of gynecologic oncology patients, who had cytoreductive surgeries, many with bowel resections. That trial was stopped due to futility after interim analysis showed no difference in the primary outcome of wound complications (17.3% wound complications in NPWT vs 16.3% in convention wound coverage, 90% CI: 0.62-1.60). The trial did notice a significant amount of skin blistering due to the NPWT compared to conventional gauze wound coverage. The authors recommended that this prophylactic intervention not be utilized to prevent wound complications. Clearly this intervention is controversial and further high-quality studies are need to sort out the true benefit.

## TABLE 8.3
## Necrotizing Fasciitis Type I and Type II

| TYPE I | TYPE II |
|---|---|
| **Incidence** | |
| 70%-80% | 20%-30% |
| **Infection** | |
| Polymicrobial[a] | Monomicrobial[b] |
| **Predisposition** | |
| Elderly | Any age |
| **Underlying condition** | |
| Yes[c] | Not necessarily |

[a]Aerobic and anaerobic bacteria.

[b]Group A Streptococcus, Methicillin-resistant *Staphylococcus aureus*, *Clostridium*.

[c]Diabetes, decubitus ulcer, hemorrhoids, rectal fissure, episiotomy, previous gastrointestinal/genitourinary/gynecologic surgery.

For wounds that heal by secondary intention, regardless of method of closure, or re-closure, this form of healing will significantly impact the patient's physical, social, and psychological domains. A recent study of patient's perceptions of open surgical wounds showed that the process of healing by secondary intention diminishes a patient's sense of self, results in an inability to fulfill social roles and obligations, and curtails normal social activities. The study highlighted the need for health care workers to improve communication by being consistent in giving information about the process of wound management and setting realistic goals about the time to complete wound healing.

# NECROTIZING SOFT TISSUE INFECTIONS

Necrotizing soft tissue infections (NSTIs) are rapidly progressive skin and soft tissue infections that cause widespread tissue necrosis and are associated with systemic illness. This newer definition has supplanted the term necrotizing fasciitis (NF) to encompass cases where necrosis extends beyond the fascia to involve the muscle, skin, and surrounding tissue although the two terms are still used interchangeably. NF is a type of NSTI characterized by friability of the superficial fascia, dishwater-gray exudate, and a notable absence of pus. These infections can occur after major traumatic injuries, after minor breaches of the skin or mucosa, after varicella infections, following nonpenetrating soft tissue injuries, following routine obstetrical or gynecological procedures, and in immunocompromised patients. The incidence and prevalence of NSTIs vary by season, location, and patient population. The annual incidence of NF ranges from 4 to 15 cases per 100 000 population with a much lower rate among obstetrical and gynecological patients (0.17-0.2 cases per 100 000 women), emphasizing the rarity of this disease, but also the need to be watchful for the vague signs and symptoms in postoperative patients. Overall mortality from these disease(s) has consistently been 20% for the last 30 years.

Necrotizing soft tissue infections can be classified based on microbiology, location, or depth of tissue involvement. Giuliano and colleagues created microbiologic profiles for NSTIs and specifically NF. NF types I and II are characterized by the kind(s) of pathologic organisms, polymicrobial (type I) or monomicrobial (type II). Type I infections account for 70%-80% of cases while type II infections account for 20%-30%. Type I NF is a polymicrobial infection involving both aerobic and anaerobic organisms and is seen in the elderly, patients with underlying illnesses, or patients during the postoperative period. Predisposing factors included diabetic or decubitus ulcers, hemorrhoids, rectal fissures, episiotomies, and surgeries of the gastrointestinal, urinary, and gynecological locations. Type I infections are usually associated with gas in the tissue and can be difficult to distinguish from gas gangrene (Type II clostridial infections). NF type II is a monomicrobial infection caused most commonly by group A streptococcus (GAS) and methicillin-resistant *Staphylococcus aureus* (MRSA) or *Clostridium spp*, among other

types of bacteria. Unlike NF type I, these infections can occur in any age group, among those without underlying or complicated medical illnesses, after surgical interventions and parturition. NSTIs can also be categorized by location with NSTIs of the head and neck causing Ludwig angina or Lemierre syndrome, perineal infections known as Fournier gangrene (male and female), and diabetic foot infections. Finally, the depth of necrosis can classify NSTIs with necrotizing cellulitis describing infections of the dermis and subcutaneous tissue, NF involving the fascia, and pyomyositis or myonecrosis describing infectious involvement of the muscle fascicle without necessarily demonstrating overlying skin infections (**TABLE 8.3**).

The vicious cycle of fulminant infection, toxin production, cytokine activation, microthrombosis and ischemia, systemic hypotension, sepsis, and death are cardinal features of NSTIs that differentiate this entity from an uncomplicated skin and soft tissue infection (cellulitis). Type II infections with GAS occur with an incidence of 3-5 cases per 100 000 population and have a high mortality rate of 29%. Mortality is even higher among patients with streptococcal toxic shock syndrome (TSS) (38% mortality) or when septic shock develops (45% mortality). There are two clinical entities of GAS NSTIs: one that occurs after a defined portal of infection (such as surgical incisions, lacerations, or insect bites) and another that arises spontaneously without an overt wound or lesion (nonpenetrating trauma like a muscle strain or bruise). In the former, the initial lesion appears only mildly erythematous, but as the inflammation progresses over the next 24-72 hours, the potent exotoxins released by the bacteria mediate inflammatory changes in the walls of the microvasculature facilitating microvascular thrombosis. The skin turns dusky and then purplish and bullae appear. The skin then rapidly becomes gangrenous and undergoes extensive sloughing. Bacteremia is frequently present and metastatic infections ensue. The pyrogenic exotoxins act as superantigens, causing rapid proliferation of T cells and production of cytokines that lead to shock and multi-organ failure.

Necrotizing clostridial infections (gas gangrene), another type II NSTI, can occur spontaneously or after traumatic injuries (70% of cases). Penetrating injuries that are deep provide the anaerobic

conditions for spore germination and bacterial proliferation. *Clostridium perfringens* account for 80% of such infections, but other clostridial species have been cultured (*C septicum, C novyi, and C histolyticum*). A specific pathogen, *C sordellii*, causes spontaneous infections in women after natural childbirth, abortion, or other gynecological procedures. These infections are characterized by an absence of fever, profound hypotension, diffuse capillary leak, hemoconcentration (hematocrit of 50%-80%), and a marked leukemoid reaction (white blood cell count of 50 000-150 000/μL whole blood). Mortality from infection with *C sordellii* is 70%-100%, occurring within 2-4 days of hospital admission.

Predisposing factors for NF among obstetrical and gynecological patients include advanced age, diabetes mellitus, obesity, a pregnant state, malnutrition, renal failure, immunosuppression, use of NSAIDs, and trauma. Combinations of these comorbid states seem to increase the risk for NSTIs.

Early diagnosis and initiation of treatment is key for favorable outcomes and minimizing mortality. However, diagnostic pitfalls interfere with early recognition of these NSTIs that require surgical intervention; differential diagnosis includes cellulitis that is treated with antimicrobial therapy. Confounding clinical signs include absence of fever, absence of early cutaneous manifestations, nonspecific radiographic testing, surgery or childbirth, and chronic underlying diseases. Clinical manifestations of NF include soft tissue edema (75%), erythema (72%), severe pain (72%), tenderness (68%), fever (60%), and skin bullae or necrosis (38%) as well as signs of sepsis such as tachycardia, hypotension, and mental status changes. A case-controlled study by Alayed et al. reported that factors differentiating NF from cellulitis include recent surgery, pain out of proportion to clinical signs, hypotension, skin necrosis, and hemorrhagic bullae. Radiographs, computed tomography scans, or magnetic resonance imaging techniques will show soft tissue swelling in GAS infection and possibly gas in the tissues of patient with clostridial gas gangrene or type I NF. The presence of gas in tissues on imaging or crepitus on physical examination should prompt immediate surgical exploration. Culture of infections and Gram stain on surgically obtained tissue is crucial for honing

antibiotic therapy. Objective criteria to distinguish mild infections from NF have been sought, and in 2004, the laboratory risk indicator for necrotizing fasciitis (LRINEC) scoring system was introduced and used total white blood cell count, hemoglobin, sodium, glucose, creatinine, and C-reactive protein to distinguish between mild soft tissue infections and NF. A score of 5.8 or greater was indicative of NF. However, subsequent studies to validate this scoring system have demonstrated a lack of sensitivity and recommended that it should not be used to rule out NF over surgical exploration.

Early surgical exploration remains the cornerstone for diagnosis and treatment of NSTIs, but identifying precise timing of intervention has been elusive due to the retrospective nature of most studies, the variable definition of time to intervention from diagnosis, recognition, or hospital admission. Nonetheless, a recent meta-analysis showed that mortality was significantly lower for patients who went to surgery within 12 hours of presenting to the hospital compared to delaying the surgery more than 12 hours (OR 0.41; 95% CI: 0.27-0.61). The absolute mortality was 19% if the surgery was completed within 12 hours vs 34% when delayed. During the surgical procedure, radical debridement of devitalized tissue to vital tissue (“cutting till you see bleeding”) is critical, often resulting in large wounds and/or reopening of a previous surgical incisions. Tissue culture and Gram stain testing is obtained from the tissue removed. In these cases where this occurs in an abdominal wound or incision, the abdomen is usually packed, the patient is left intubated, and aggressive resuscitation and intensive care are needed. In addition, reexploration and debridement use of to remove all necrotic tissue is often needed within 12-24 hours to lower mortality. Since these procedures lead to large wounds, closure of these wounds can be challenging requiring use of synthetic materials or tissue flaps or both and reconstruction consult.

Taken altogether, a multidisciplinary approach for the care of NF patients is needed and includes differing surgical specialists, intensivists, and infectious disease specialists. Empiric, broad-spectrum antibiotics are started once the diagnosis is made, usually simultaneously with planned operative intervention, and before culture results return. Because most of these infections are

polymicrobial, beta-lactam-beta-lactamase inhibitor combination (such as piperacillin-tazobactam) or carbapenem (such as meropenem or imipenem) with or without vancomycin should infection with *S aureus* be a concern. Clindamycin can be considered, not for its activity against anaerobes but for its ability to inhibit ribosomes and the synthesis of exotoxins. As culture results return, antibiotic therapy is tailored to susceptibilities. Antibiotic therapy should continue for 10-14 days.

Through the years, certain adjunctive therapies have emerged to aid in the treatment of these critically ill patients in the postoperative period. The use and benefits of hyperbaric oxygen therapy (HBO) remains controversial and should never delay surgical débridement. While older studies of this therapy showed no benefits, newer observational studies have suggested benefit. Currently, several randomized control trials are ongoing to assess the benefit of HBO therapy in conjunction with surgical débridement and antibiotic treatment. Intravenous infusion of immune globulin (IVIG) also remains controversial for use in NF although patients with GAS infections may be a subgroup that could benefit from such treatment. The rationale for IVIG lies in its ability to neutralize key extracellular toxins that mediate shock and multi-organ failure.

# WOUND DEHISCENCE AND EVISCERATION

Wound dehiscence is one of the most dreaded and serious postoperative complications associated with open abdominal surgery. The incidence of wound dehiscence (*evisceration or burst abdomen*) in gynecological surgery is 0.3%-0.7% and occurs in 0.4%-3.5% of all abdominal surgeries. Unfortunately, the mortality of this condition continues to be 10%-44%. Despite better perioperative care, availability of newer suture material, and better closure techniques, the rates of wound dehiscence have remained constant for the last four decades.

Technically, wound dehiscence means separation of all layers of the abdominal incision but has been termed differently based upon

which layers of tissue have disrupted. Superficial dehiscence means separation of the skin and all tissue layers posterior to the skin to the fascial layer, but the fascial layer remains intact. If the fascial layer is partially disrupted, this form of dehiscence is termed incomplete or partial dehiscence. However, if the disruption includes the peritoneum, it is called a complete wound dehiscence. Finally, should the intestine protrude through the wound, the term *evisceration* (also known as a *burst abdomen*) is used (**TABLE 8.4**).

## TABLE 8.4
## Types of Wound Dehiscence

| | |
|---|---|
| Superficial | Fascia intact |
| Partial | Fascia partially disrupted |
| Complete | Fascia completely disrupted |
| Evisceration/Burst | Fascia disrupted and bowel protruding |

The pathogenesis of wound dehiscence is divided between surgeon-related and patient-related factors. The type of incision, the technique of closure, the choice of suture material, and attempts at controlling perioperative infection are all under the surgeon's control. Patient-related factors include age >65 years, poor nutritional state, mechanical factors—such as wound hematomas, paroxysmal coughing and gastrointestinal problems (retching, vomiting, ileus), and rapid accumulation of malignant ascites—chronic pulmonary diseases, chronic steroid use, hemodynamic instability, emergency surgery, and wound infection. Interestingly, intercourse, foreign body presence in the wound, and diabetes have not been independently shown to increase wound dehiscence.

The type of incision has been shown to be associated with the incidence of wound dehiscence with transverse and paramedian incisions having lower rates of wound dehiscence than midline

incisions. And although wound dehiscence has been reported with Pfannenstiel incisions, a systematic review showed a trend toward lower rates of wound dehiscence and evisceration with transverse incisions compared to midline incisions. In the past, type of closure as well as type of suture was associated with wound dehiscence. Several systematic reviews have shown that type of closure (mass vs layered) and choice of suture (slowly absorbable vs nonabsorbable) had no impact on wound dehiscence rates. When wound dehiscence occurs early in the postoperative course, the most common cause is the quality of the suture technique. Maintenance of a SL-to-WL ratio over 4 and utilizing a continuous closure vs interrupted are both associated with low rates of dehiscence and evisceration. Complete wound dehiscence and evisceration can be problems associated with tissue failure and not suture failure, with the main mechanism being suture cutting through tissue. If the suture holding tissues disintegrates due to a necrotizing infection, this usually occurs 7-10 days after wound closure, as it takes time for an infection to develop. However, rates of severe SSI causing dehiscence or evisceration are quite low (0.1%).

Eviscerations usually occur from day 5-14 after operation, with a mean of about 8 days. One of the early signs of complete dehiscence and impending evisceration is the seepage of serosanguineous pink discharge from an apparently intact wound. This sign occurs in 23%-84% of cases and can be present for several days before evisceration occurs. Although occult hematomas are usually the cause of such discharge, these wounds need to be examined carefully, by probing the wound between staples or sutures with a cotton-tipped swab to assess the integrity of the fascial closure. Frequently, the patient is conscious of something giving way, “tearing,” or “popping” immediately before the burst abdomen becomes clinically apparent.

When evisceration is noted, the bowel can be replaced into the incision by using sterile gloves, gently packing it in place with lap pads soaked in saline and securing it with an abdominal binder. Broad-spectrum antibiotics should be initiated, and baseline blood counts and serum electrolyte studies should be obtained with the intent of returning the patient to the operating room emergently.

Because of the rarity of this situation, it is prudent to consult a surgeon with expertise in managing complex wound complications (ie, trauma surgeon, hernia surgeon).

Currently, evidence to guide the management of the burst abdomen is very poor. A review by van Ramshorst et al. found that management options reported in the literature are not directed by prospectively designed trials and that outcome data reported are variable or absent. Nonoperative management is an option for patients with small defects or if the health status of the patient is tenuous and does not allow for immediate surgery. This option includes covering the wound with saline-soaked gauze with wet-to-dry dressing changes daily. Alternatively, NPWT can be employed with planned delayed closure once the condition of the patient improves. If the wound is clean or clean-contaminated, the cause for the burst abdomen is a failed suture technique, and/or the fascial edges are clean and of adequate substance, primary closure can be attempted using a slowly absorbable, monofilament suture in a mass running technique with small bites and maintaining an SL:WL ratio of 4:1 or greater. If intra-abdominal pressure (IAP) is high, or anticipated, or the fascial edges are ragged or retracted, primary fascial closure will likely fail or not be possible. These situations will likely require placement of synthetic mesh in clean wounds and biological mesh with or without NPWT in the presence of infection. If the cause of the burst abdomen is an infection, the cause of the infection needs to be identified (intra-abdominal abscess or anastomotic leak) and controlled. Other operative techniques include placing relaxing fascial incisions and tissue flaps to close the incision. The subcutaneous tissue and skin are usually left open and packed for later delayed closure or NPWT placement.

Use of retention sutures is controversial. However, if the wound edges are ragged or the patient’s medical condition is poor, a through-and-through retention suture of no. 2 nylon or polypropylene is used. The sutures are placed at least 2.5-3 cm from the skin edges and are passed through all layers. To allow for edema, these are placed 2 cm apart. To prevent inclusion of the underlying intestine in a suture, all sutures are held up before the first one is tied. Skin edges unopposed between the through-and-through

sutures can be approximated with interrupted 3-0 polypropylene. The through-and-through sutures should be left in place for 3 weeks. A nasogastric tube should be used in the immediate postoperative period to avoid abdominal distension, and broad-spectrum antibiotics should be continued and modified according to culture results. (**FIG. 8.16**)

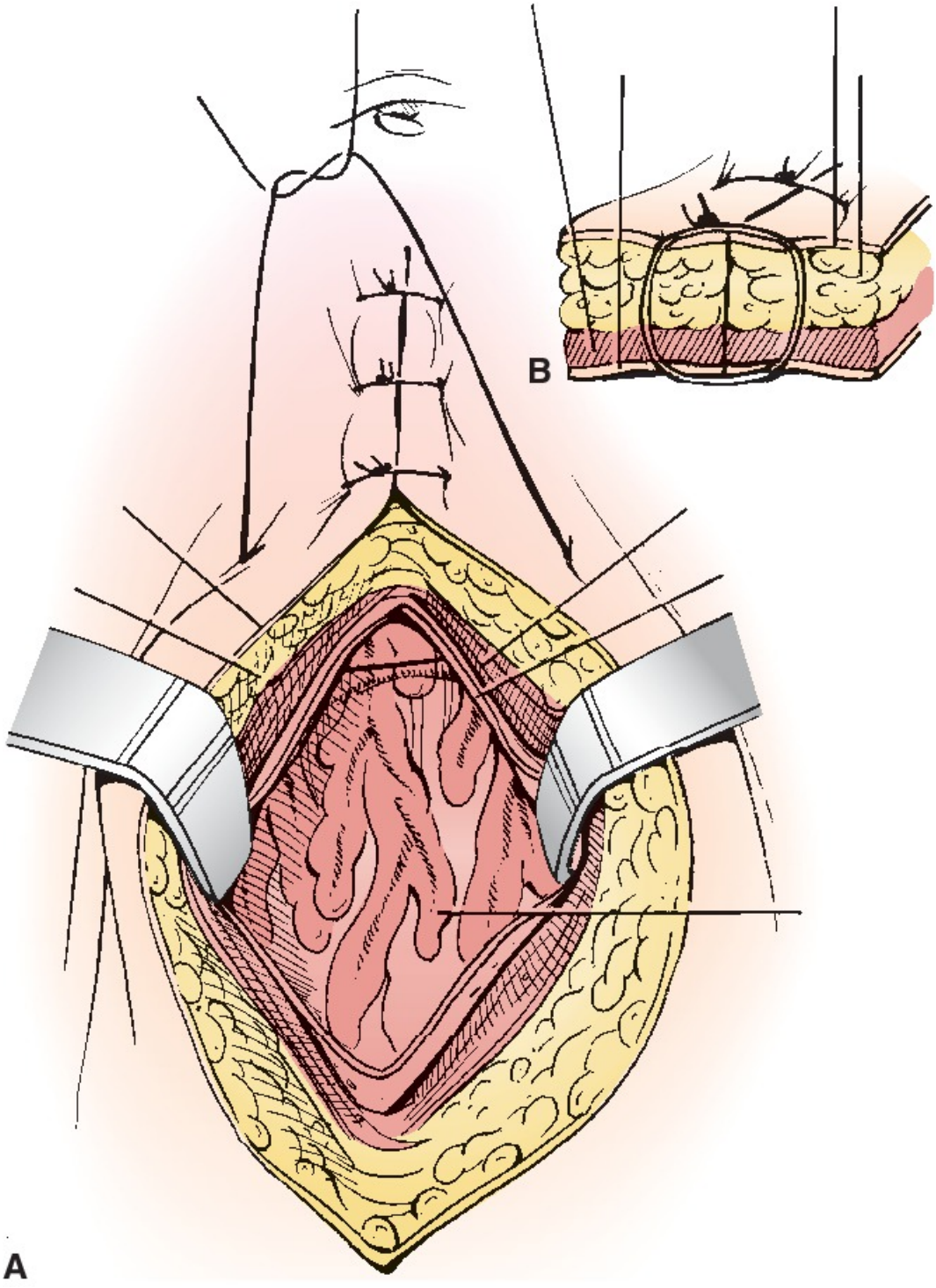



**FIGURE 8.16 A.** Secondary closure of an evisceration with retention sutures (usually no. 1 polypropylene sutures—rubber dams can be

included) and preferably no. 2 polypropylene sutures. **B.** All layers are incorporated.

The complications of a burst abdomen include recurrent burst abdomen, IH formation, enterocutaneous fistula formation, and death. Because the fascia is already damaged from the initial surgical closure and the dehiscence, failure of closure is high and recurrent dehiscence rates vary between 0% and 35%. Despite the interventions listed above, the mortality of a burst abdomen remains 10%-44% and is primarily due to cardiopulmonary complications and infection. IH formation is very high in patients with a burst abdomen, even if repaired primarily.

# INCISIONAL HERNIA

Incisional hernia (IH) is a frequent late complication after midline incisions (and less frequently in transverse incisions) for gynecological surgery. Rates of IH after abdominal midline surgeries have been estimated to be 2%-20%. A recent review of the Swedish National Quality Register on the topic, with 5 years of follow-up, revealed a low 2% IH rate among patients who had open gynecologic surgeries. However, the IH rate more than doubled to 5% for obese patients, a well-known risk factor for this complication. Several studies have shown that it takes time for hernias to occur. Since most studies of incidence of hernias have follow-up at or <12 months, the actual rates of IH are likely to be underreported. Hernias occur where fascial edges and adjacent muscles separate with the peritoneum intact, leaving a defect beneath the subcutaneous tissue into which the bowel and omentum can herniate. Although the initial fascial defect may be small, the size of the resultant hernia sac can assume varying proportions and involve the entire length of the lower abdominal wall. The size of the hernia depends on the mobility of the bowel and omentum and the final aperture size of the defect. The smaller the fascial defect through which small bowel can herniate,

the greater the frequency of incarceration, obstruction, and infarction.

Ventral hernias cause significant morbidity for patients: they can increase in size, worsen an individual's ability to function, cause skin breakdown, or incarcerate and strangulate requiring emergency surgery, outcomes of which are poor. In addition, elective repair can be complex and associated with high rates of complications including SSI rates of 20%-30% and hernia recurrence rates of 20%-30%. It is estimated that the United States spends $3.2 billion annually on the surgical management of ventral hernias. Each major complication after surgical management of a ventral hernia repair costs the health care system $30 000-$210 000 to address.

The incision choice will impact the rate of IH, with fewer hernias occurring with transverse incisions. Despite extensive research on suture material (slowly absorbable vs nonabsorbable) to close midline incisions as well as type of closure (running vs interrupted), no material or method of closure has emerged to reduce IH rates. However, ensuring an SL:WL ratio of >4:1 and taking small bites (5 mm back and 5 mm apart) to attain the SL:WL ratio have been shown to lower IH rates.

Patient risk factors that have been associated with development of IH include obesity (BMI ≥ 30 $kg/m^2$), rectus diastasis >25 mm, anemia, diabetes, cachexia, increasing age, emergency surgery, coronary artery disease, smoking, chronic obstructive pulmonary disease, history of operation for abdominal aortic aneurysm, corticosteroid use, and preoperative uremia. Other risk factors for development of postoperative hernia include vertical incision, ascites related to liver disease, obesity, gynecologic malignancies, an acute intra-abdominal inflammatory process, and smoking (**TABLE 8.5**).

## TABLE 8.5
## Risk Factors for Development of Incisional Hernias

| |
|---|
| Obesity |
| Rectus diastasis >25 mm |
| Anemia |
| Diabetes |
| Cachexia |
| Increasing age |
| Emergency surgery |
| Coronary artery disease |
| Smoking |
| Chronic obstructive pulmonary disease |
| Previous surgery for abdominal aortic aneurysm |
| Corticosteroid use |
| Preoperative uremia |
| Vertical incision |
| Ascites related to liver disease |
| Gynecologic malignancies |
| Acute intra-abdominal inflammatory process |
| Smoking |

Fifty percent of patients with ventral hernias report symptoms of lower abdominal discomfort and a varying degree of abdominal distension. Patients with large hernias may note bowel peristalsis beneath the skin and report that the bulge becomes smaller when they are in a recumbent position. The hernia is more noticeable during coughing and straining and can increase in size over time because of enlargement of the hernia ring and/or incorporation of additional segments of bowel into the hernia sac. Diagnosis of IH has traditionally relied on physical examination driven by patient symptoms. This examination included inspection and palpation of the abdominal wall with the patient in a supine and standing position and with and without Valsalva maneuvers. If the hernia is large and/or apparent, physical examination is adequate for diagnosis, but detection of IH in an obese patient is often difficult. CT scanning is considered the noninvasive gold standard to diagnose IH. However,

exposure to ionizing radiation, evaluation of the patient in a static supine position, and the cost of the study are significant drawbacks. Beck et al. compared dynamic abdominal sonography for hernia (DASH) to CT imaging for detection of IH. They found that DASH had high sensitivity (98%) and specificity (88%) as well as high positive (91%) and negative (97%) predictive values. Advantages of DASH include the ability to obtain real-time results, the ability to perform the test bedside with the patient in several positions, and the complete lack of exposure to ionizing radiation.

# KEY POINTS

- Preoperative counseling for surgery should include discussion of location of the incision, rationale for incision choice, and any potential incisional complications.
- Fascial closures (of midline and some transverse incisions) should be accomplished with delayed absorbable monofilament suture. Plain catgut or chromic catgut should *never* be used for fascial closures.
- Closed drainage systems (ie, Jackson-Pratt or Blake) should be used when drains are considered. Passive drains, such as Penrose drains, should not be used.
- For superficial wound dehiscence of wounds due to seroma, hematoma, or infection, consider NPWT over delayed closure and secondary-intention closure with wet-to-dry dressing changes for improved patient healing. Delayed closure in the office may be less expensive and more convenient for the patient compared to NPWT.
- NF is a fulminant NSTI that has vague symptomatology that can delay diagnosis. However, immediate and aggressive surgical exploration is needed when diagnosed to reduce mortality.

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# CHAPTER 9

# PRINCIPLES OF LAPAROSCOPY

Amanda Yunker

**Preparation for Laparoscopy**
Patient Selection and Contraindications
Operating Room Setup
**Laparoscopic Equipment**
Basic Equipment
Other Laparoscopic Tools
**Peritoneal Entry**
Umbilical Entry
Palmer Point Entry
Alternative Entry Sites
**Initial Laparoscopic Entry**
Veress Needle Technique
Hasson Open Technique
Optical Direct Entry Technique
Preoperative Ultrasound Slide-by Test
Accessory Trocar Placement
Risks Associated With Entry
**Diagnostic Laparoscopy**
**Operative Pelvic Spaces**

Retropubic Space
Paravesical Space
Pararectal Space
Vesicovaginal Space
Rectovaginal Space
Presacral/Retrorectal Space
**Tissue Extraction**
**Closure**
**Complications**
Vascular
Urinary Tract
Gastrointestinal
Nerve Injury
**Special Populations**
Pediatric Patients
Obese Patients
Pregnant Patients
Geriatric Patients

The origins of endoscopy as a method to examine body cavities through natural orifices have been documented as early as 936 AD. Arabian physician Abulkasim is credited with attempting to use light reflection to examine the cervix. However, without modern advances such as electricity and metalworking, little advancement in this area occurred until the 1800s. The Frankfurt physician Bozzini is among the first inventors of the actual endoscope. His creation in 1805 was a crude metallic tube used to visualize the urethra, with a candle as its light source. This was dismissed as a “toy.” Fifty years later, Desormeaux invented what is considered the first useable

endoscope for examination of the urethra and bladder. In the 1870s, Stein incorporated photography into endoscopy. Nietze modified this technique, and he is considered the father of modern cystoscopy. In 1880, Edison invented the lightbulb, which was followed in 1901 by the first “peritoneal endoscope,” invented by George Kelling, a German surgeon. The technique was originally called “celioscopy” and was performed on a dog. At the same time, von Ott, a Russian gynecologist, performed endoscopy on a human peritoneal cavity using a head mirror and speculum via a small abdominal incision. Finally, in 1912, Jacobaeus, a Swedish surgeon, utilized Nietze’s cystoscope to illuminate the peritoneal cavity and reported on 42 examinations of the abdomen. He is credited with the terms “laparoscopy” and “thoracoscopy.” From there, the inventions of gaseous distention, electrosurgery, and modern anesthesia have transformed laparoscopic surgery to what it is today.

In the practice of gynecology, laparoscopy is one of the most utilized surgical procedures because of its many indications. For most general gynecologists, laparoscopy is employed as a diagnostic tool. Several pelvic disease conditions cannot be easily diagnosed with radiologic tests, and laparoscopy is the gold standard. These include endometriosis, pelvic adhesive disease, unexplained fertility, and, at times, ectopic pregnancy. The most common indication for diagnostic laparoscopy is pelvic pain. **TABLE 9.1** lists common laparoscopic indications.

## TABLE 9.1
## Gynecologic Indications for Laparoscopy

| |
|---|
| Pain |
| Presence of foreign body |
| Hysterectomy |
| Adnexectomy |
| Sterilization |
| Fertility assessment and treatment |
| Endometriosis |
| Fibroids |
| Uterine and adnexal masses |
| Pelvic adhesions |
| Ectopic pregnancy |
| Appendectomy |
| Cancer staging and treatment |

# PREPARATION FOR LAPAROSCOPY

## Patient Selection and Contraindications

As with all surgical procedures, appropriate patient selection is the first step to reducing surgical risk and optimizing patient outcome. Most patients who are safe to undergo surgery will be candidates for laparoscopic surgery. Careful selection of patients for laparoscopy is important because of known medical comorbidities that make this procedure problematic for some patients (**TABLE 9.2**).

## TABLE 9.2
## List of Contraindications for Laparoscopy

| |
|---|
| **Absolute** |
| Inability to tolerate pneumoperitoneum or Trendelenburg |
| Increased intracranial pressure |
| Abnormalities of cardiac output/cardiac or pulmonary disease exacerbated by pneumoperitoneum or Trendelenburg |
| Hepatomegaly |
| Splenomegaly |
| **Relative** |
| Pregnancy (dependent on gestational age) |
| Severe obesity |
| Extensive pelvic adhesions |
| History of ventral hernia surgery |
| Presence of large ventral hernia |

# Operating Room Setup

Laparoscopy requires specific equipment. In addition to the surgical instruments, the room will need to accommodate a "tower," which houses the carbon dioxide outflow, camera base, and light source. This tower may or may not be attached to a monitor or screen which the surgeon(s) will view throughout the case. Depending on the area of operation (pelvis vs upper abdomen), the screen may need to be moved to allow the surgeon to view it without craning his/her neck. The ideal setup for pelvic surgery is one to two monitors placed near the foot of the patient. The room must also allow for a generator of

some sort in which to attach the electrosurgery instruments. It is imperative that all cords and cables be fixed or taped to prevent tripping or entanglement (**FIG. 9.1**).

**A**

**FIGURE 9.1** **A.** Ergonomic surgical suite with ceiling-mounted, movable flat screens. **B.** Close-up of the tower, which includes the camera input (*top*), the light source (*middle*), and insufflation control (*bottom*).

The bed is ideally in the center of the operating room, allowing full movement around the patient. This bed must allow lithotomy positioning, the ability to tuck patient arms, allow for change in patient height, tilt, and angle, and Trendelenburg positioning. There are a variety of materials that surgeons will affix to the bed to prevent their patients from sliding cephalad while in Trendelenburg. The least expensive options include egg-crate foam, memory foam, and gel pads. There are more expensive commercially available options such as air mattresses, bean bags, and foam pads with attached Velcro straps (**FIG. 9.2**).

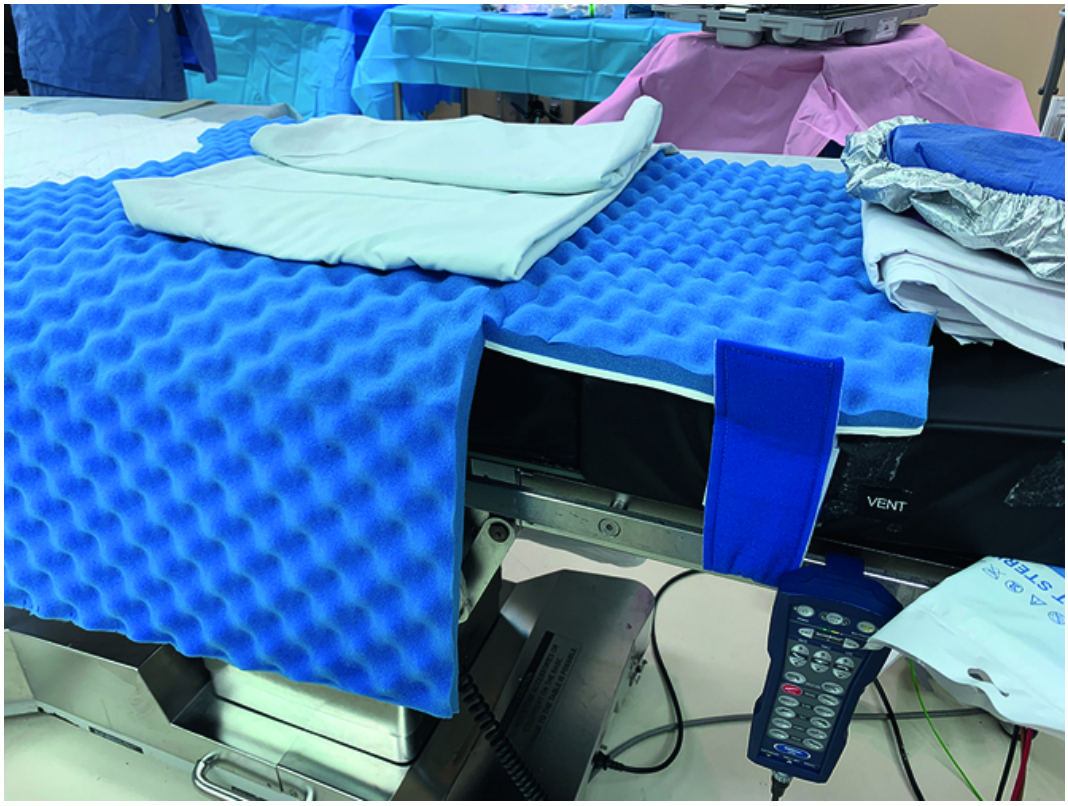



**FIGURE 9.2** Inexpensive egg-crate is placed on operating room table to decrease patient movement when placed in Trendelenburg position.

The patient should be placed on the OR table in low lithotomy position once anesthesia has been induced. The legs should be supported by padded stirrups, and the buttocks at or slightly below the inferior edge of the bed to allow access to the vagina and perineum and adequate uterine manipulation. The angle between the thighs and abdomen should be around 170°; hip flexion to an angle of <150° or more than 180° puts the patient at increased risk of nerve injury. The angle of the knee should be between 90° and 120°, and the hip abduction angle should be 90° or less. The toes, ankle, and knee should be in a straight line with the umbilicus and contralateral shoulder. Chapter 5 on safe positioning describes additional precautions to avoid injury.

Most surgeons tuck both arms next to the patient in military position (thumb up) to allow free movement around the operating table. By not extending the arms at the sides the risk of incurring a brachial plexus injury is reduced. The neck-shoulder angle should be 90° to avoid overstretch (either up or down) of the brachial plexus. Padding should be used liberally at any point where there is pressure against the patient, especially over bony prominences. Many surgeons will perform a Trendelenburg “tilt test” prior to draping to determine the risk sliding cephalad during the case and confirm respiratory tolerance to anesthesia in this position.

Depending on planned surgery, most laparoscopists require bladder drainage as a full bladder can obscure the operative field and increase risk of bladder injury. For short procedures, some surgeons will ask the patient void prior to moving to the OR or perform an in-and-out catheterization at the time of sterile prep. Foley catheter placement is preferred for longer surgeries. An orogastric or nasogastric tube should be placed if there is a plan to place an upper abdominal trocar such as when entry is planned at Palmers point. Intraoperative uterine manipulation is required for certain procedures to provide adequate pelvis visualization or exposure. Many uterine manipulators are available for this purpose, in both reusable and disposable forms. Some devices have a channel through which chromopertubation can be performed. In addition to optimizing positioning, and port placement, choosing the most effective manipulator is important to enhance surgical field visualization (see **FIG. 9.3** and **VIDEO 9.1**).

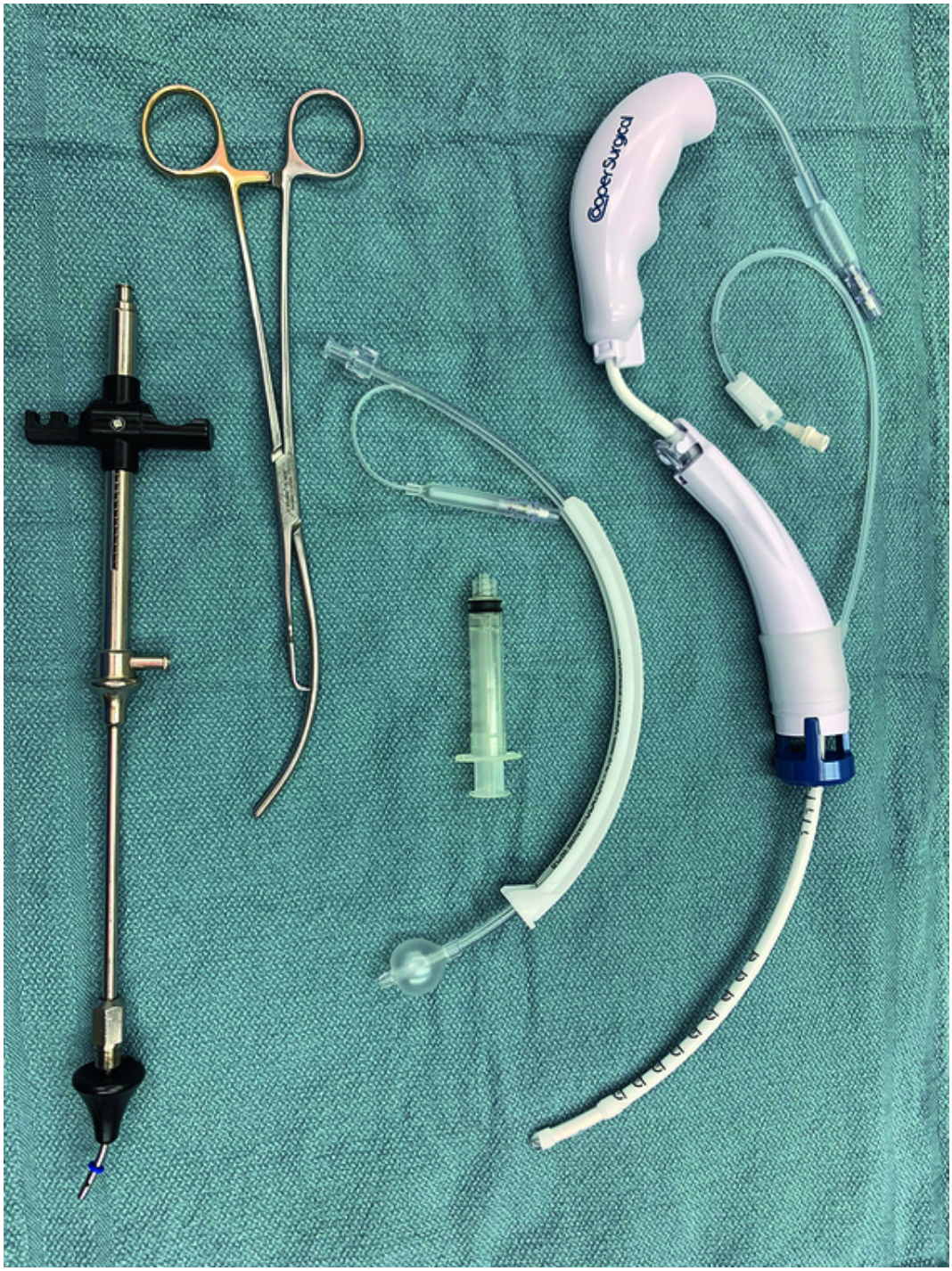



**FIGURE 9.3** Uterine manipulators. From *left* to *right*: Acorn uterine manipulator, Hulka uterine tenaculum, Zumi (Zinnanti Uterine Manipulator/Injector), Advincular Delineator

Cooper Surgical. Other manipulators not shown: Rumi manipulator Cooper Surgical and VCare manipulator ConMed.

# LAPAROSCOPIC EQUIPMENT

## Basic Equipment

Most procedures that were previously performed using an open approach are now performed laparoscopically. The equipment is quite different, and surgeons who perform laparoscopy must be familiar not only with the procedural steps but also with the required equipment in order to trouble-shoot when equipment failure occurs and identify alternative instruments for use when needed.

Laparoscopic surgery requires abdominal distention with carbon dioxide gas for visualization and operative space. Use of carbon dioxide is advantageous in that it is rapidly absorbed by blood and has no long-term effect on metabolic status. Insufflators are designed to deliver gas in a sterile manner, through fitted tubing (which attaches to a trocar or Veress needle), and at a rate that is adjustable to a desired pressure level. The insufflator is usually housed in the tower with the camera box and light source. The source of carbon dioxide is either from a tank or from a central gas supply. The target pressure for most laparoscopic surgeries in a generally healthy adult patient is 15 mm Hg. The opening pressure measured by the insufflator is one indicator of location (intraperitoneal vs extraperitoneal) of the Veress needle or entry trocar; it is advantageous for the surgeon to be able to see the insufflator pressure reading during initial entry.

A camera head, laparoscope, and light source comprise the remainder of the standard equipment for diagnostic laparoscopy. Together with the output monitors, these make up the imaging system. These, too, are often housed in the tower. Newer systems are equipped with a printer and/or video recorder. Laparoscopes range in diameter from 1.8 to 12 mm and are available with various

viewing angles (0°, 12°, 30°, 70°). Most laparoscopy is performed using a 5- or 10-mm 0° scope. The light source is a fiberoptic cable, which attaches to the scope and transmits light from a high-intensity light source, such as xenon or halogen. The end of the cable that attaches to the scope can be extremely hot and can cause skin or drape burns and needs to be handled cautiously. The camera head attaches to the scope over the eyepiece and has several handheld control buttons for picture-taking, zoom, or white balance. Most cameras transmit high-definition images.

## Other Laparoscopic Tools

Operative laparoscopy requires a variety of tools that are placed through the accessory ports. A variety of instruments are available to assist with tissue manipulation: blunt probes; graspers with and without teeth, curved or straight, blunt-tipped or pointed; laparoscopic tenacula; and bowel retractors. The surgeon should choose the most appropriate grasper for the tissue type and desired tension. For instance, a toothed grasper should never be used to retract bowel. Most graspers are reusable (**FIG. 9.4**).

**FIGURE 9.4** Ancillary instruments for laparoscopic surgery. Shown from *left* to *right*: Maryland dissector, atraumatic forceps, biopsy forceps, and bowel grasper. A Maryland dissector is used when grasping small pieces of tissue or when separating planes, such as during an ovarian cystectomy. An atraumatic grasper provides excellent grip and does not traumatize the tissue. A biopsy forceps has a small sharp tooth, which can provide added grip but does create a small puncture. A bowel forceps allows for atraumatic manipulation of the bowel and can

be used for blunt dissection. (© KARL STORZ SE & Co. KG, Germany.)

Laparoscopic scissors are available in reusable and disposable options. They can be “cold”—that is, not attached to an electrosurgical generator, or fitted with a monopolar cord and be a source of electrical energy as well as a cutting device. Other instruments available for performing incisions include the laparoscopic scalpel, monopolar or bipolar hooks and spatulas, staplers, harmonic scalpels, and bipolar cutting forceps. Many of these are reviewed in the Chapter 7 on electrosurgery. A laser is also an option for tissue incision. Surgical lasers available for laparoscopic use include $CO_2$, argon, potassium titanyl phosphate, and ndYAG. These are typically fitted to the camera head, a suction-irrigator, or handheld device. Monopolar and bipolar energy are both options in laparoscopic surgery and are used to incise or provide hemostasis.

Understanding how to obtain hemostasis during laparoscopic surgery is particularly important; the surgeon needs to be skilled in a variety of approaches. Options for obtaining hemostasis in laparoscopic surgery include use of suture, vascular clips, staplers, and chemical agents. Laparoscopic suture can be placed in a variety of ways. Long internal incisions, such as the vaginal cuff or a cystotomy, are often closed in a running fashion or with multiple interrupted sutures. Knots can be tied with intracorporeal or extracorporeal throws. Extracorporeal knots are thrown and secured with a knot-pusher, which is passed through an accessory trocar. Tying intracorporeal knots requires a specific skill set and laparoscopic needle drivers. The knots are tied within the abdomen using the needle driver to perform an “instrument tie.”

Laparoscopic preknotted sutures are available. The endoloop is an example of this. The loop comes fixed to a plastic rod, which passes the loop through a trocar and into the abdomen. The loop is then cinched down around the pedicle and a pretied knot is pushed toward the base of the pedicle with the rod.

In more recent years, use of barbed suture has become popular. There are at least two commercially available barbed sutures. The advantage of barbed suture is the ability to secure the suture without knot-tying. The suture is pulled through the tissue with the barbs pointing away from the direction of the needle. Then, as it is tightened in the tissue, the barbs “catch” the tissue and hold. Barbed suture is a popular choice for vaginal cuff closure and hysterotomy closure during myomectomy.

Laparoscopic surgical clip appliers are available in a variety of sizes. Endosurgical clips offer the advantage of precise hemostasis on a vascular pedicle near vital structures, where electrosurgery may not be safe. Surgical staplers both divide and secure hemostasis of a pedicle. They are most often used during laparoscopic appendectomies and bowel excision or anastomosis. Once secured across the pedicle, the stapler is fired, releasing staggered rows of staples. Most require a 10-mm port for introduction into the abdominal cavity.

A variety of chemical hemostatic agents are available for use in open cases as well as laparoscopic surgery. These are applied topically over the tissue in an area of bleeding, when other approaches have failed, or the anatomy lends itself to a powder or fluid application. They serve as an adjunct to the normal human coagulation cascade and function in either a mechanical or biological role. Mechanical agents create a scaffold for platelets to adhere. They come in many forms for use, including cloth, foam, sponge, and powder. Biologic agents include products that contain thrombin and fibrin and work to increase clot formation. These products come in liquid form. See Chapter 39 for discussion of hemostatic agents. These are applied topically over the tissue in an area of bleeding when other approaches have failed. Hemostatic agents are introduced through a specific applicator through a port and laparoscopic graspers can direct application to the bleeding site.

# PERITONEAL ENTRY

Most gynecologic surgeons consider initial entry into and insufflation of the peritoneal cavity to be the surgical step with the highest risk,

given that it is mostly blind. Multiple studies have compared entry methods, with the overall conclusion that surgeons are safest with the technique with which they are most comfortable. The location of primary entry, choice of entry technique and device, and placement of accessory trocars are all critical elements for successful and safe laparoscopic procedures.

## Umbilical Entry

The umbilicus has multiple advantages as a location for primary laparoscopic entry and port placement. It is the mid-point of the abdomen, both in the superior-inferior axis and left-right axis, thus allowing for equal visualization of all parts of the abdominal cavity for a thorough diagnostic view. The layers of the anterior abdominal wall fuse at a point at the base of the umbilicus, where there is an absence of muscle (thus it is a weak area and prone to hernia). The fusion of several fascial structures in the umbilical ring reduces the number of layers a trocar or Veress needle must puncture before entry into the peritoneal cavity. Additionally, because nerve roots and abdominal wall vessels originate laterally and attenuate as they travel medially, there are very few superficial adjacent nerves or blood vessels at the umbilicus. The umbilical incision is also preferred because the incision can be successfully hidden in umbilical folds and is minimally noticeable.

The anatomy posterior to the umbilicus, however, does pose significant risk. In most patients, the umbilicus sits immediately over the bifurcation of the aorta into the left common and right common iliac trunks. This relationship changes with more obese patients, with the umbilicus moving in a more inferior location in relationship to the bifurcation (**FIG. 9.5**).

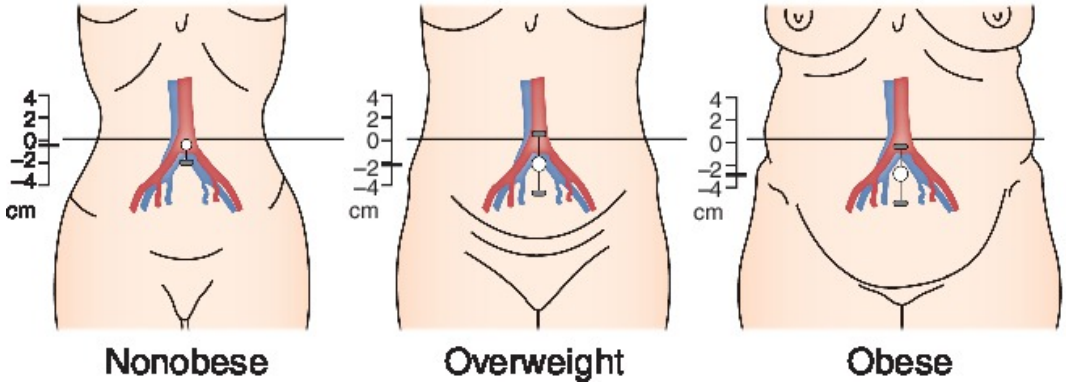



**FIGURE 9.5** The location of the umbilicus and its relation to the major vessels in nonobese, overweight, and obese patients. (Modified with permission from Hurd WW, Bude RO, DeLancey JO, et al. The relationship of the umbilicus to the aortic bifurcation: implications for laparoscopic technique. *Obstet Gynecol*. 1992;80(1):48-51. Copyright © 1992 by The American Congress of Obstetricians and Gynecologists.)

## Palmer Point Entry

Palmer point is named for Raoul Palmer, MD, a French gynecologist who described this technique in 1947. Palmer point is located 3 cm below the left subcostal margin in the midclavicular line. Surgeons often choose this location for initial entry if they are concerned about abdominal adhesions from prior surgery. Palmer point is usually adhesion free (except potentially in patients with prior bariatric procedures) and can be accessed by direct optical view port placement or Veress needle entry. The stomach should be deflated with an orogastric or nasogastric tube prior to insertion. A disadvantage of Palmer point is its distance to the deep pelvic structures and longer instruments may be required to perform pelvic

surgery. This is not a common area for open Hassan technique (**FIG. 9.6**).

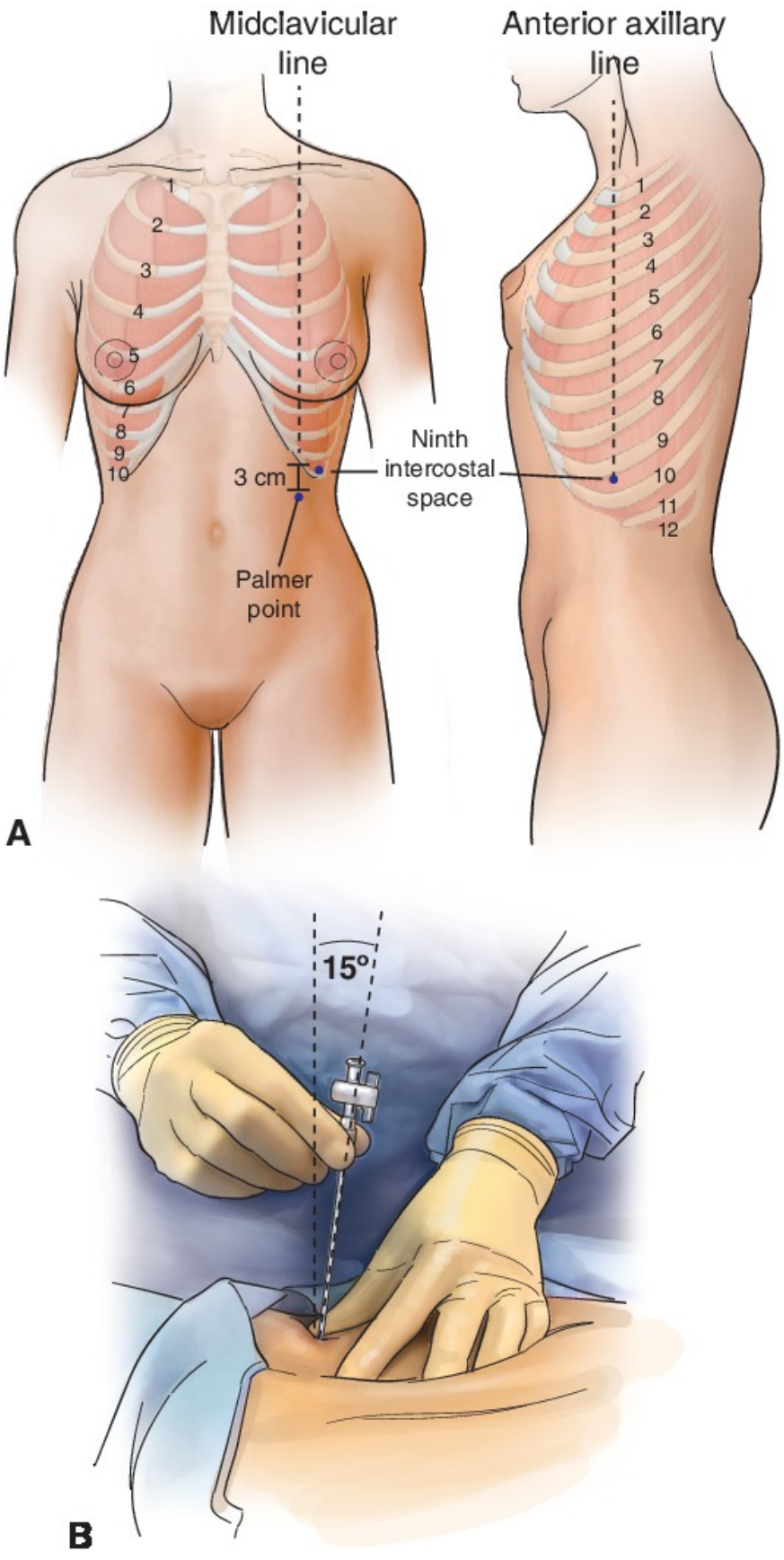

Midclavicular line
Anterior axillary line
1
2
3
4
5
6
7
8
9
10
11
12
3 cm
Ninth intercostal space
Palmer point
A
15°
B

**FIGURE 9.6** **A.** Palmer point located 3 cm caudad to the left costal border, in the midclavicular plane. **B.** The Veress needle is inserted 15° cephalad from the long axis of the patient.

## Alternative Entry Sites

Initial entry using sites other than the umbilicus or Palmer point have been reported and can be safe alternatives. These include the left 9th intercostal space, the posterior cul-de-sac, and left or right paraumbilical region. The left 9th intercostal space is an entry point specifically for placement of a Veress needle. Entry is made at the anterior axillary line, between the 9th and 10th ribs, grazing the top of the 10th rib. The abdominal peritoneum is very adherent to the ribs in this area. Adjacent structures that are at risk with this entry include the spleen, stomach, and neurovascular bundle, which runs along the inferior edge of the 9th rib.

The posterior cul-de-sac in most patients is an adhesion-free area, and it is notable that posterior colpotomy during vaginal hysterectomy is a blind procedure as well. Thus, this location could be utilized to obtain pneumoperitoneum. Similar to the 9th intercostal space, the posterior cul-de-sac is utilized for Veress placement, and not typically trocar placement, though direct optical entry has been reported. The colon and sacral promontory anatomy would be at risk for injury during this entry. A thorough rectovaginal exam must be performed prior to initiating entry; findings of nodularity, immobility, or suspicion of endometriosis are contraindicated for this technique.

The left and right paraumbilical areas are entered similar to Palmar point entry and are associated with similar risks. These sites are closer to the deep pelvis and thus may be more advantageous as operative ports. The surgeon should consider the anatomy of the anterior abdominal wall prior to entry, location of abdominal wall

vasculature, that multiple layers will be encountered, and that the liver will be near the right insertion site.

# INITIAL LAPAROSCOPIC ENTRY

## Veress Needle Technique

Veress needles can be disposable or reusable. Regardless of type, both must be tested before use to confirm that the exterior needle retracts easily when pressure released. When the Veress is placed against pressure (the abdominal wall fascia in most circumstances), the inner blunt tip is pushed inside the surrounding needle apparatus and thus the fascia is incised until penetrated. Once placed, location of the needle into the peritoneal cavity is confirmed by observing opening pressure, using the hanging drop test, or saline injection (**FIG. 9.7**).

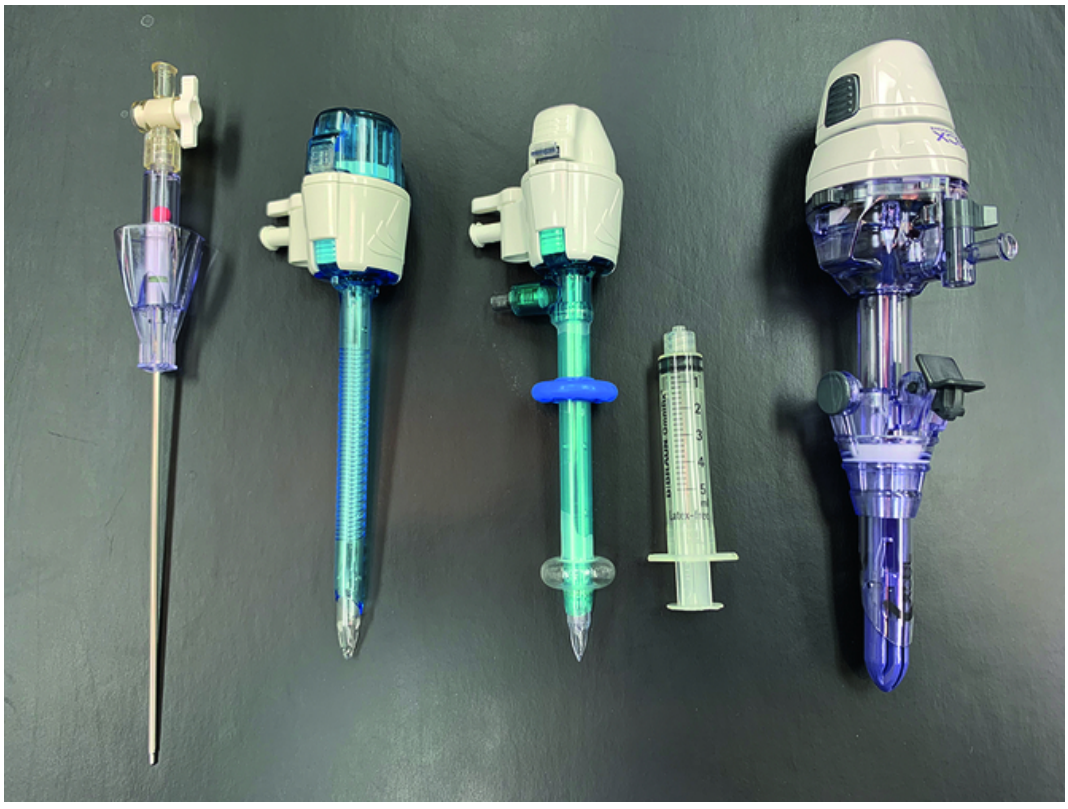


**FIGURE 9.7** Types of laparoscopic trocars and Veress needle. From *left* to *right*: Veress needle and trocar ports: trocar sleeve without balloon 5 mm (Applied medical), trocar sleeve with balloon tip 5 mm (Applied medical), XCEL Hassan trocar sleeve, 10 mm (Ethicon).

The patient should be in a neutral supine position. An incision is made at the base of the umbilicus, Palmer point, or paraumbilical region. The anterior abdominal wall is grasped and retracted away from the needle site. The angle of entry between the needle and abdominal wall should be 45°-90°, depending on location, adiposity, and underlying anatomic structures. The surgeon will feel a series of "pops" as the needle passes each layer. Closer to the midline, fewer pops will be felt. After placement, the needle is attached to tubing connected to the insufflator and the opening pressure of the peritoneal cavity should be <10 mm Hg. If using the hanging drop technique, a drop of saline is placed in the top of the Veress needle. When the abdominal wall is lifted, the negative pressure of the abdomen pulls the drop into the Veress needle. A similar result occurs with the saline syringe test where a small amount of saline is injected without resistance (**FIG. 9.8**).

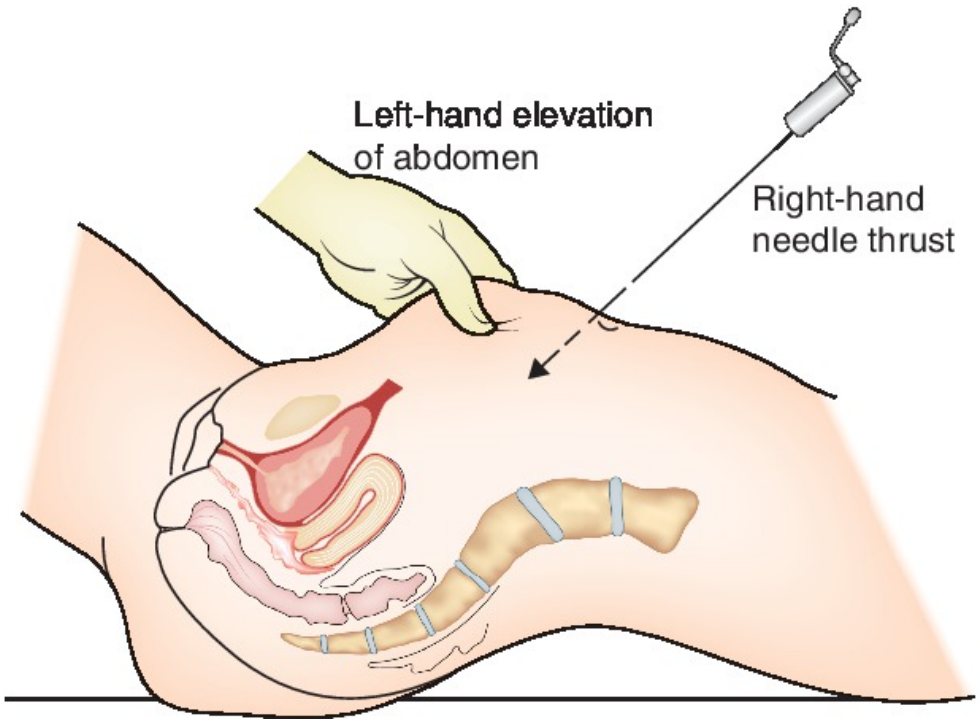



**FIGURE 9.8** Insertion of the Veress needle.

This entry technique has the advantage of achieving pneumoperitoneum prior to trocar placement, thus distending the abdomen creating distance between subsequent secondary trocar placement and underlying anatomic structures.

## Hasson Open Technique

Harrith Hasson described this technique in 1971. The Hasson entry is an open technique where the initial incision is carried through all layers, including peritoneum, and the Hasson trocar is affixed to the fascia once is it placed in the abdominal cavity. It is called open because the surgeon can visualize and confirm abdominal entry before placement of the laparoscopic trocar. This entry technique has the advantage of avoiding vascular injury. It also allows for easier fascia closer at the close of the procedure in that those layers are pretagged. In obese patients, this entry can be more complicated (**FIG. 9.9**).

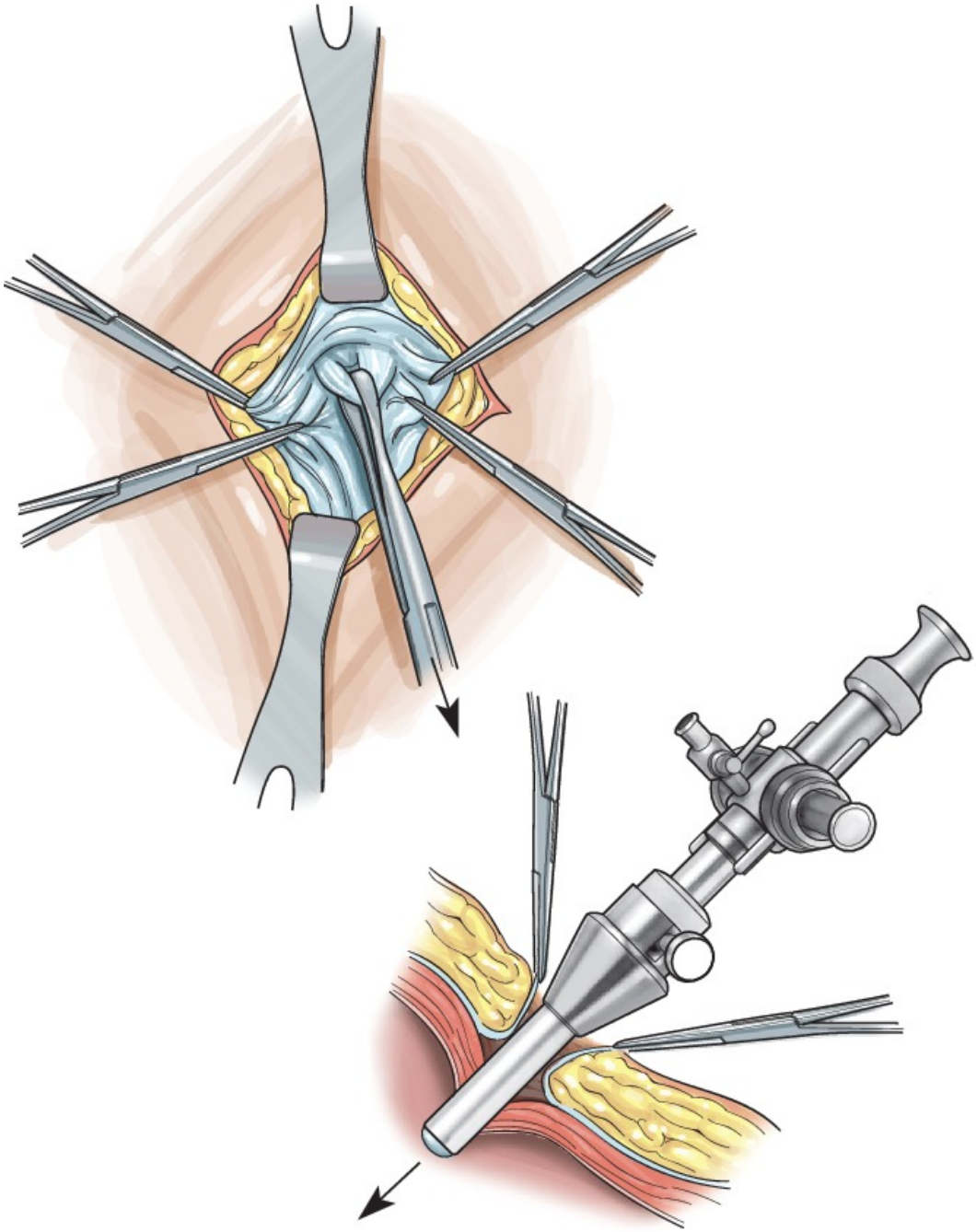


**FIGURE 9.9** Hasson trocar placement. The skin is incised at the base of the umbilicus, either parallel or perpendicular to the long access of the patient. Dissection is carried down until the fascia is visualized. This is

typically performed bluntly using S or Army Navy retractors. The fascia is grasped at the lateral aspects with Allis or Kocher clamps, tented, and incised sharply using scissors. The peritoneum is entered sharply under direct visualization. A suture is placed at each angle of the fascial incision. The Hasson trocar is inserted into the fascial incision and anchored in place with the lateral sutures. The anchoring sutures are later used to facilitate fascial closure.

A 10- to 12-mm vertical or semilunar incision is made in the skin at the base of the umbilicus and the edges are grasped and elevated with Allis clamps. Using blunt dissection, the periumbilical fat is dissected, and the fascia is identified. Kocher clamps can be used to elevate the fascia and Mayo scissors used to incise it and enter the abdominal cavity. The peritoneum is closely approximated to the fascia at this point and is often simultaneously entered at the time of incision. Alternatively, the fascial edges can be grasped and everted and the peritoneum entered under direct visualization. The Hasson cannula is introduced directly into the abdominal cavity. The fascial edges are tagged and wrapped around the Hasson cannula port.

## Optical Direct Entry Technique

With the introduction of transparent trocar sheaths with insufflation capacity, optical direct entry has become a common choice among surgeons who feel this entry technique is now safer. These cannulas come in a variety of diameters, allow for the attachment of the laparoscopic scope, and include attachment for insufflation tubing. Many surgeons describe this technique as the combination of direct trocar placement and Veress needle insufflation.

An incision is made at the base of the umbilicus, Palmer point, or paraumbilical area with the scalpel; the incision should be large enough to accommodate the chosen trocar. A 0° scope is then placed in the trocar and insufflation tubing is attached. While tenting the abdominal wall, the scope and trocar are placed in the incision at a 90° angle and gently rotated while applying gradual pressure. The tip of these trocars is sharp and dissect layer of fascia and fat well. The layers of the abdominal wall can be seen as the trocar advances so the surgeon can be aware of progress through the wall. Final placement in the peritoneal cavity is met with a “flutter” of tissue as the $CO_2$ gas fills the abdominal cavity. Once sufficient abdominal distention is achieved, the trocar can be advanced, and the obturator removed.

The advantage of this technique is the ability to directly visualize abdominal wall layers during entry. Disadvantages of this approach include the risk of preperitoneal insufflation if the surgeon pauses in that space too long or is mistaken that complete entry has occurred ( **VIDEO 9.2**).

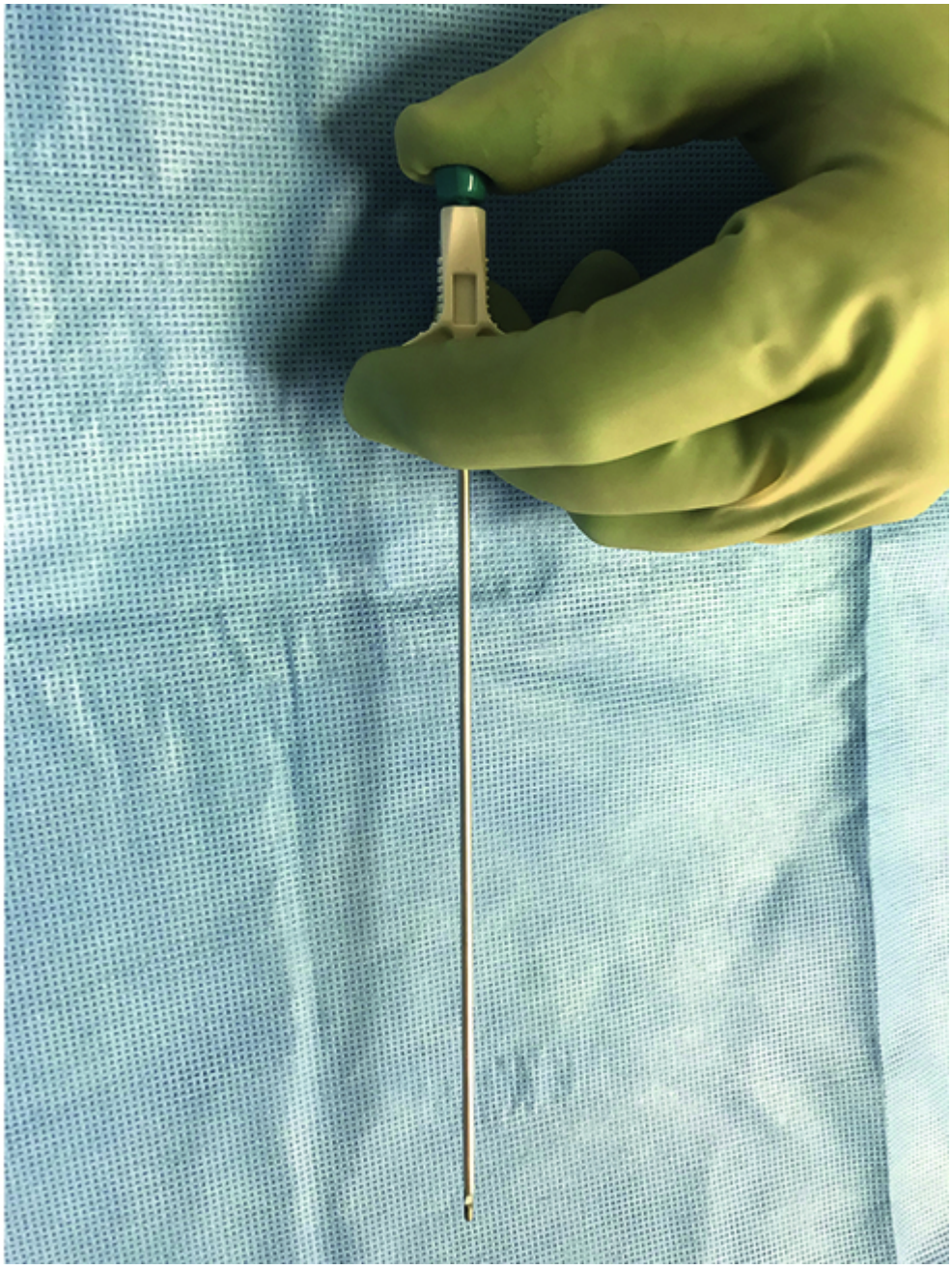
# Preoperative Ultrasound Slide-by Test

A major objective of initial trocar placement is avoiding injury to adjacent visceral organs, specifically the bowel and major vessels. While the first trocar placement is essentially blind, the ultrasound slide-by test can reliably predict the presence of intra-abdominal adhesions below the planned entry site. This approach involves placing an abdominal ultrasound probe on the patient’s abdomen while they are awake (preferably at all potential areas of initial trocar entry) and asking the patient to take large breaths. The abdominal wall layers and abdominal viscera are identified, and with sonography, abdominal viscera “slide-by” of at least 1 cm should be observed along the abdominal wall with each breath. This test has a high sensitivity and specificity for the detection of intra-abdominal adhesions.

# Accessory Trocar Placement

Operative laparoscopy requires the placement of additional trocars (the number being dependent on the planned procedure and complexity of anatomy) to allow the surgeon access to the operative site and to utilize two hands to operate. One principle of laparoscopic surgery is the concept of triangulation: placing accessory ports in locations that allow the surgeon to approach the surgical area from different sides (lateral/medial or anterior/posterior). Triangulation allows for traction-countertraction, tissue retraction, adequate dissection, and suturing.

Surgeons have different preferences for the location of accessory trocars: lateral, suprapubic, paraumbilical, etc. There is also variation on size of trocar utilized for assistance. Most surgeons elect to use smaller trocars, usually 3 or 5 mm, for accessory ports. However, planned specimen removal may dictate the size of trocar utilized. A larger specimen will require a 10- or 15-mm port for extraction. There are also vessel sealing devices and staplers, which require larger port sizes. Three- and five-millimeter laparoscopic incisions typically do not require closure of the fascial layer. However, 10 mm and above will require closure of the fascial incision. This can be performed using a fascial closure device or routine fascial closure can be performed at the conclusion of the case (**FIG. 9.10**).



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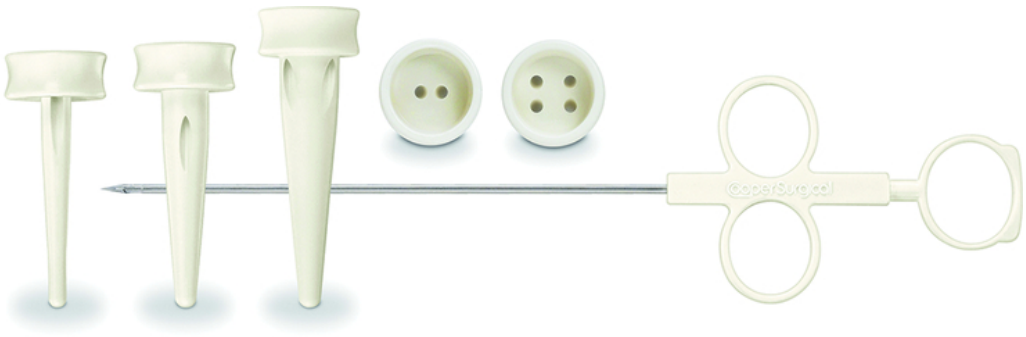


C

D

**FIGURE 9.10** Fascial closure devices. **A.** Endo Close. (Courtesy of CooperSurgical, Inc.) **B.** Weck EFx. (Courtesy of Teleflex, Inc., Research Triangle Park, NC.) **C.** Carter-Thomason. (Courtesy of CooperSurgical, Inc.) **D.** Carter-Thomason II. (Courtesy of CooperSurgical, Inc.)

All ports should be placed at a 90° angle to the abdominal wall to avoid an oblique entry, which can lead to inadvertent injury to abdominal contents and vessels, difficulty obtaining entry in obese patients, and competition for space with an adjacent port.

## Risks Associated With Entry

While placement of accessory trocars is inherently safer in that they are now placed under visualization from the camera port, there is still the risk of injury, and the surgeon must be familiar with underlying and abdominal wall anatomy to avoid injury. Lateral trocars can injure the inferior epigastric vessels, the ilioinguinal or iliohypogastric nerves. The path of the inferior epigastric vessels along the anterior abdominal wall can be easily identified using transillumination from the abdominal cavity outward. These vessels can be seen emerging superiorly from the triangle formed by the medial umbilical ligament (medially) and the lateral exit of round ligament through the inguinal canal (laterally). The trocar should be placed lateral to their path but superior to the anterior superior iliac spine (ASIS). The ilioinguinal and iliohypogastric nerves travel along lateral border of the psoas muscle and then enter the transversus abdominis near the anterior border of the iliac crest. These nerves pierce the internal oblique within 3 cm medial and 3.5 cm inferior to the ASIS. Thus, trocar placement inferior the level of the ASIS increases the risk for injury to these nerves (**FIGS. 9.11** and **9.12**). A general guide for placement of lateral ports is to place lower quadrant ports 2 cm medial to and superior to the anterior superior iliac spine, with care to place these lateral to the rectus border.

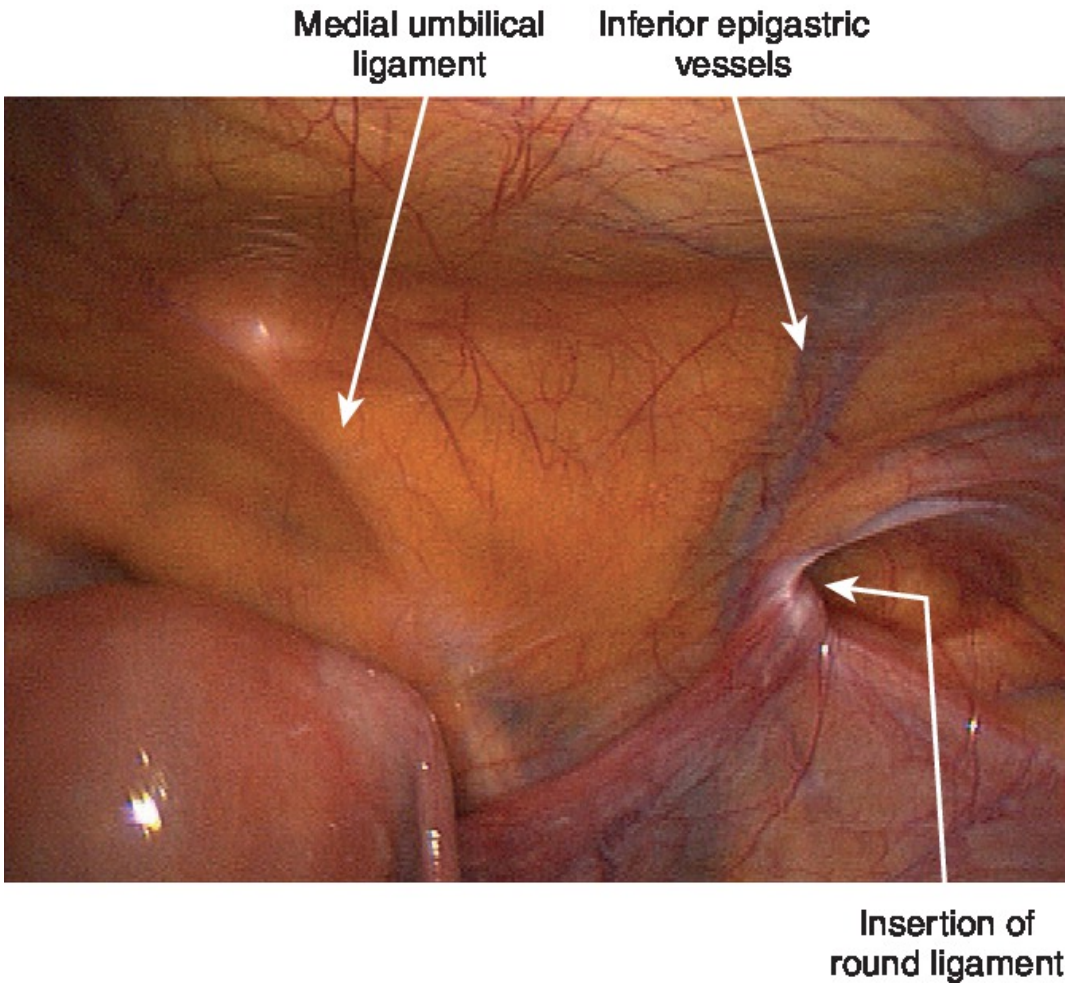



**FIGURE 9.11** Note the relationship of the inferior epigastric vessels to the medial umbilical ligament and the insertion of the round ligament.

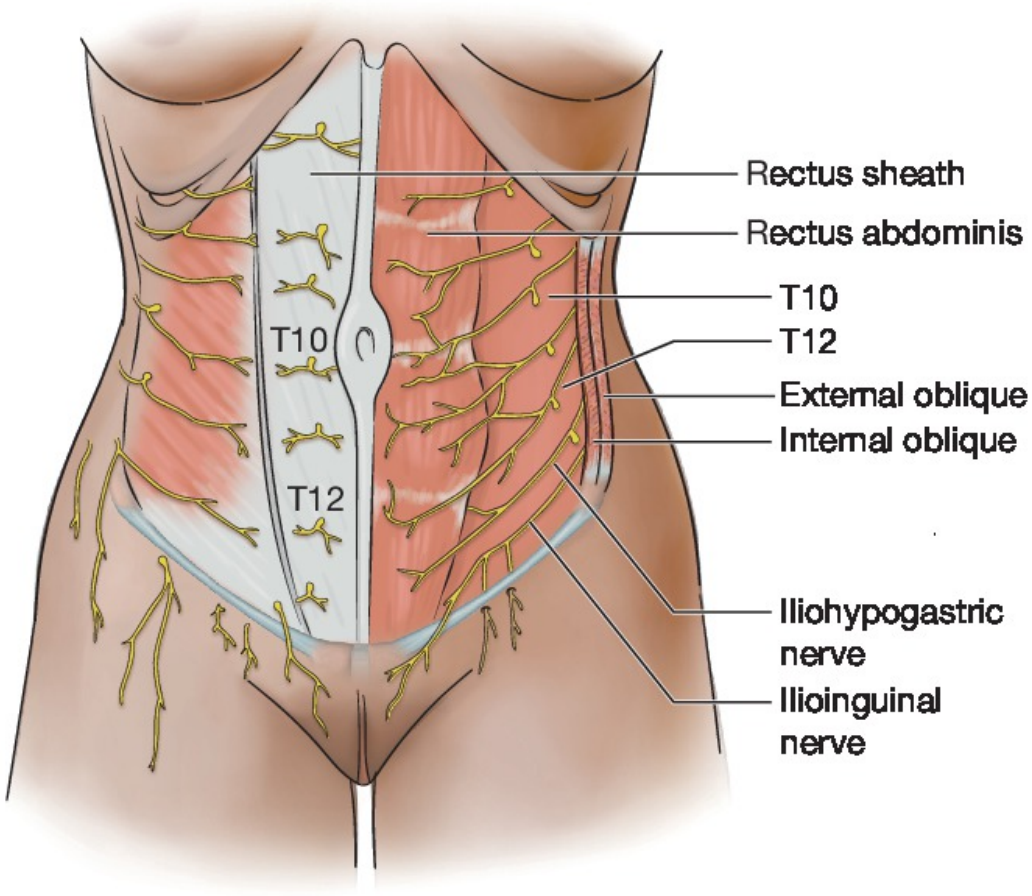



**FIGURE 9.12** Location of ilioinguinal and iliohypogastric nerves, below ASIA.

The urinary bladder is at risk of injury when a suprapubic port is placed. This port should be at least 2 cm superior to the pubic symphysis and the bladder drained prior to trocar placement. If the patient has a history of prior pelvic surgery, specifically laparotomy, the bladder may be in a more superior location and the trocar should

be placed in a higher location. The bladder can be backfilled if there is any uncertainty to the location of the bladder.

# DIAGNOSTIC LAPAROSCOPY

Laparoscopy is a valuable tool for the diagnosis of many pelvic and abdominal disorders.

Diagnostic laparoscopy should be performed systematically, and all findings (or absence of) should be documented. After initial trocar insertion, the upper abdomen is examined prior to patient placement in Trendelenburg position. The surgeon should note the appearance of the liver, gallbladder, diaphragm, omentum, and stomach and document any pathology noted. Once in Trendelenburg, the pelvic organs are surveyed. To optimize visualization of the pelvis, the bowel is gently swept into the upper abdomen, starting with the omentum, then small and large bowel. If the small bowel needs detailed assessment such as in cases of suspected injury, the surgeon can evaluate the bowel laparoscopically. Beginning at the ileocecal junction, the small bowel is grasped with two atraumatic graspers and passed “hand-over-hand” in 5- to 10-cm segments, moving proximally from ileum to jejunum to duodenum. The large bowel is usually in a fixed location and can be followed from ascending to transverse (posterior to omentum) to descending colon with minimal manipulation (**TABLE 9.3**).

## TABLE 9.3
## Checklist for Systematic Diagnostic Laparoscopy Survey

| |
|---|
| Ovaries |
| Fallopian tubes |
| Uterus |
| Uterosacral ligaments |
| Round ligament |
| Ureters |
| Appendix |
| Upper abdominal organs |
| Diaphragm |
| Anterior cul-de-sac |
| Posterior cul-de-sac |
| Ovarian fossae |
| Hernia |
| Endometriosis |
| Adhesions |

Once the bowel is swept from the pelvis, the surgeon should systematically survey all gynecologic organs (uterus, both fallopian tubes, ovaries), the appendix, anterior and posterior cul-de-sacs, and ovarian fossae, noting the presence or absence of endometriosis, fibroids, cysts, adhesions, or abnormal anatomy.

Chromopertubation can be performed at the time of laparoscopy to assess fallopian tube patency. There are several choices of uterine cannula devices that allow injection of dilute methylene-blue or indigo carmine through the device, into the uterine cavity, and through the fallopian tubes. Lack of spill may be due to tubal

obstruction, spasm, or poor seal at the uterine cervix. If blue fluid is seen vaginally, a larger cannula or placement of a cervical clamp can be placed to prevent leakage of dye through the cervix.

# OPERATIVE PELVIC SPACES

Laparoscopic surgeons should be comfortable with all pelvic anatomy, including the retroperitoneal spaces, which will often be entered during a planned or unplanned procedure. These spaces can be entered atraumatically and are where the major vessels, lymph nodes, nerves, and ureter are identified.

## Retropubic Space

The retropubic space, also known as the prevesical space or space of Retzius, is bordered posteriorly by the bladder, anteriorly by the pubic symphysis, and laterally by the arcus tendinous fascia. This space is opened during pelvic support procedures. It can be entered by backfilling the bladder (which allows the border of the bladder to be identified but also retracts the bladder posteriorly with gravity), gently grasping the median umbilical ligament, and incising the ligament.

## Paravesical Space

The paravesical space is bordered by the bladder medially, the cardinal ligament posteriorly, the pelvic sidewall (obturator internus and levator ani) laterally, and the pubic ramus anteriorly. Gynecologic surgeons enter this space to identify the ureter as it enters the trigone, perform colposuspension procedures, complete a pelvic lymphadenectomy, or radical hysterectomy.

## Pararectal Space

The pararectal space is bordered medially by the rectum, anteriorly by the cardinal ligament, laterally by the ureter/internal iliac artery, and posteriorly by the sacrum. This space is further divided, by some

surgeons, into the “medial” pararectal space—where the ureter is still a lateral border—and the “lateral” pararectal space—where the ureter is now part of the medial border. The pararectal space is opened when there is obliteration of the posterior cul-de-sac, and it is safer to isolate the disease from a lateral approach. This space is also entered during a radical hysterectomy.

## Vesicovaginal Space

This space is also contiguous with the vesicocervical space and is commonly referred to as the anterior cul-de-sac. This midline space is bordered posteriorly by the uterus (cervix/vagina), anteriorly by the bladder, and laterally by the bladder pillars. It is most commonly entered during a hysterectomy, especially when removing the cervix with the uterine body.

## Rectovaginal Space

The rectovaginal space, also a midline space, is bordered anteriorly by the vagina/uterus, posteriorly by the rectum, and laterally by the uterosacral ligament. It is also referred to as the posterior cul-de-sac. This area is a common place for excision of deep infiltrating endometriosis. It is also entered from the vagina during a vaginal hysterectomy and allows the surgeon to ligate and divide the uterosacral ligament.

## Presacral/Retrorectal Space

The presacral (also called retrorectal space) is bordered anteriorly by the rectum, posteriorly by the sacrum, and laterally by the ureter and internal iliac vessels. In a more superior location, this is referred to as the presacral space and is the location of the superior hypogastric nerve plexus. The presacral space is entered during presacral neurectomy, sacralcolpopexy, and lymph node dissection. There are multiple major vessels in this location (**VIDEO 9.3**).

# TISSUE EXTRACTION

Small benign tissue samples, such as biopsies and endometriosis implants, can be removed through a 5- or 10-mm port. Larger specimens, such as fibroids, adnexal structures, or the appendix, often require removal in a bag. There are several options for laparoscopic retrieval bags. These come in a variety of sizes and are made of nonporous materials, such as polyurethane or ripstop nylon. They usually require a 10- to 15-mm trocar for deployment. The bag is deployed in the abdomen, the specimen placed in the bag, and bag edges delivered through the incision until visible externally. If the specimen is small enough, it will pull through the incision once the trocar is removed. If not, the incision must be extended (with care taken to avoid cutting the bag) or the specimen must be removed in smaller pieces (while remaining in the bag) (**FIG. 9.13**).

**FIGURE 9.13** Specimen retrieval bag. The bag is usually introduced through a 10-mm port. The plunger (handle) is depressed and the operator places the specimen in the bag. The bag is cinched closed by pulling the ring,

and the metal banjo is removed under direct visualization by pulling the plunger (handle).

Larger specimens can be delivered with or without bag through a mini-laparotomy or a posterior colpotomy. A colpotomy incision can be made by placing a sponge stick vaginally posterior to the cervix, applying superior traction, and incising between the uterosacral ligaments with laparoscopic scissors or hook with the sponge as a backstop until it is visualized. To visualize the sponge stick more easily, it can be dipped in methylene blue (**FIG. 9.14**).

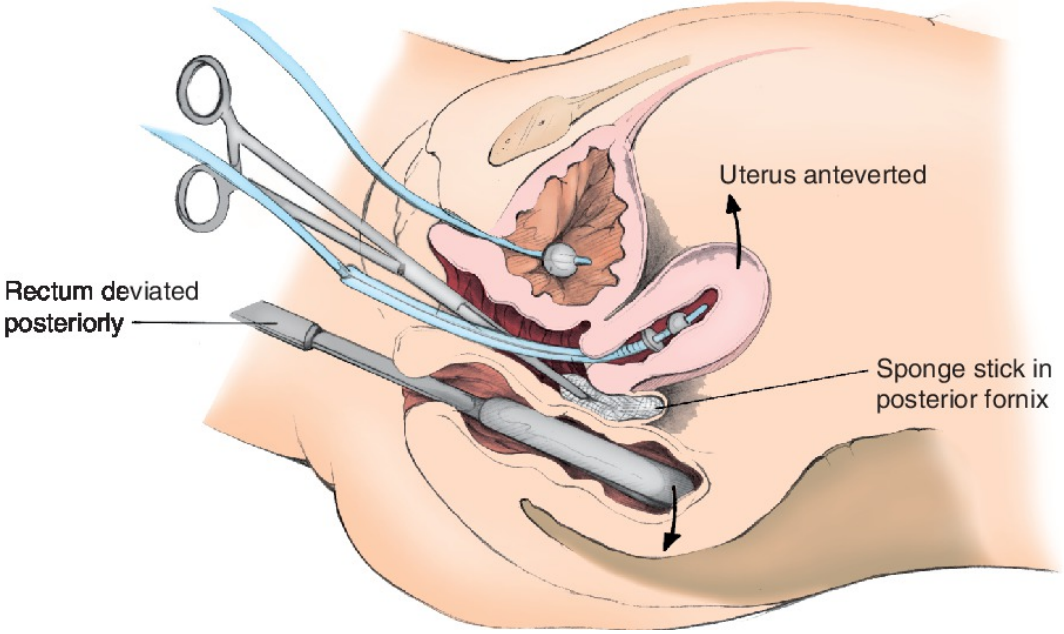



**FIGURE 9.14** Dissection of the posterior cul-de-sac. Placing instruments in the uterus, posterior fornix of the vagina, and rectum help define the anatomy.

Larger tissues, such as fibroids or the uterus, require morcellation for removal if the vaginal canal cannot accommodate them or is not the

planned extraction route. Contained (in a bag) morcellation is now preferred, both to prevent the spread of an undiagnosed malignancy and to facilitate complete removal of the specimen. There are a variety of bags available for utilization during contained tissue extraction. These vary in size, and some are reusable. Once the specimen is placed in the bag, and the bag edges exteriorized (either vaginally or via mini laparotomy), the tissue is then extracted in a stepwise fashion using any number of techniques (wedge resection, paper roll, apple core, etc.) (**FIG. 9.15**).

**FIGURE 9.15** Extraction bags for contained hand morcellation. Alexis Contained Extraction System (Applied medical) ranges from 14 to 17 cm in size and can be deployed through a 2.5- to 4-cm incision for specimen extraction. (© 2020 Applied Medical Resources. All rights reserved.)

# CLOSURE

Once hemostasis has been noted and all specimens have been removed, the pneumoperitoneum should be reversed before the last port is removed. This will allow the patient's metabolic state to return more quickly to normal conditions and reduce postoperative pain due to retained $CO_2$. There are several approaches to reversing pneumoperitoneum: giving a series of large manual breaths, leaving normal saline in the abdominal cavity, and then adding the breaths, or washing the peritoneal with dilute lidocaine. Providing five large breaths prior to removing the last trocar seems to result in significant pain reduction with very little risk to the patient.

Closure of the vaginal incision is reviewed in Chapter 24 on hysterectomy. The fascial layer of the individual port sites require closure if they are over 8 mm in size. A delayed absorbable suture is preferred. These can be closed in a traditional manner by grasping the fascial layer and reapproximating it with one or several figure-of-8 stitch depending on the size of the incision. For patients with thick abdominal walls such as the obese patient, identifying the fascia may be difficult. In these patients, a fascia closure device may be used. These devices require closure under direct laparoscopic visualization so the laparoscope should still be positioned in the abdomen. The device either deploys the suture into the abdomen, which then autoretrieves the suture, or the device creates a passageway along which the surgeon passes the suture and then

retrieves on the opposite side. Once the fascial layer is closed, the skin incisions can be closed with suture, surgical glue, or staples as per surgeon preference.

# COMPLICATIONS

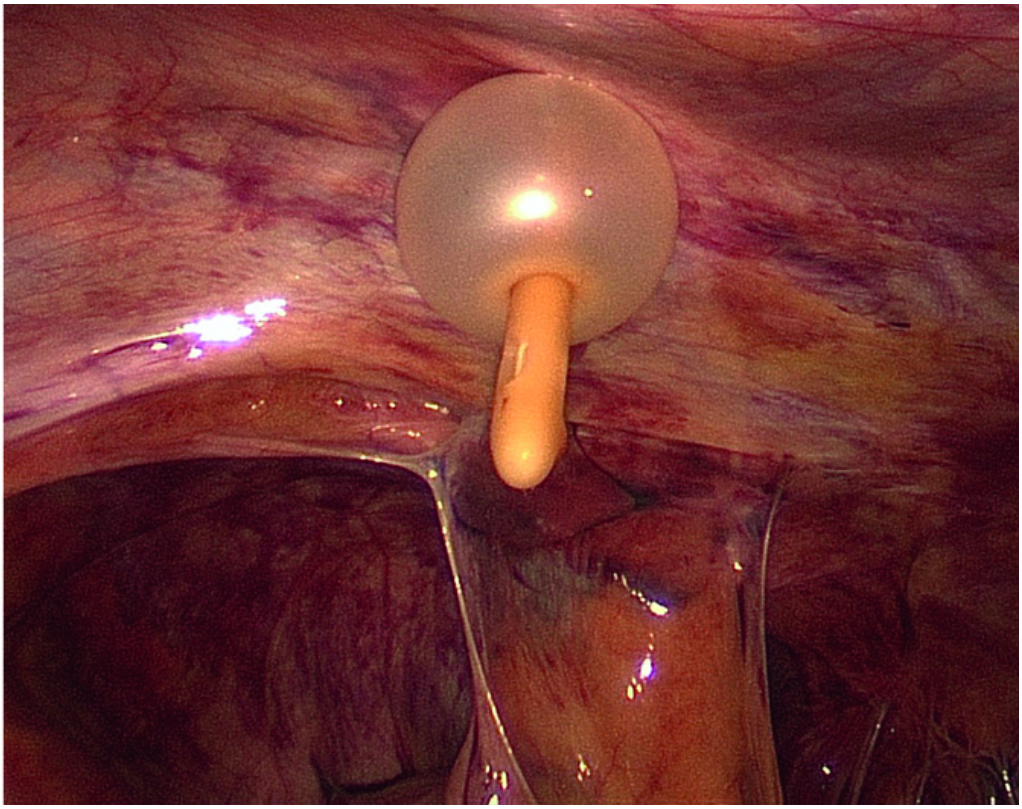
While all surgeries carry risk of complications, there are unique risks related to laparoscopic surgery. The major areas of risk are reviewed here.

## Vascular

Vascular injuries can occur on initial entry or anytime during the laparoscopic procedure. These are the most life-threatening injuries that can occur during laparoscopy. The great vessels overlying the presacral space are at highest risk for injury during umbilical entry, with either the Veress needle or the trocar. Immediate recognition of a vascular injury is critical. If injury to a vascular vessel occurs, immediate laparotomy is recommended, and pressure should be applied on the injured vessel while plans are made to repair the injury either with the assistance of other surgeons or specifically a vascular surgeon. The anesthesia team must be notified immediately so that venous access can be optimized, and blood prepared for transfusion if needed.

Lateral trocar placement has the potential to injure the inferior epigastric vessels, which run cephalad along the anterior abdominal wall peritoneum, after branching off the external iliac artery. To avoid injury, the surgeon should identify this vessel prior to lateral trocar insertion. If there is injury to the inferior epigastric artery or vein, it can be tamponaded in a few ways. A Foley catheter can be introduced though the trocar site, inflated intra-abdominally, and placed on tension by placement of a clamp against the skin to tamponade the bleeding site. Another method is to place two sutures, one inferior to the injury and the other superior to it, through the abdominal wall. A Keith needle with Prolene works well for this. The sutures are tied externally over a surgical sponge and left for 24 hours. They can then be removed at bedside. Minor vessel injuries

can be controlled with bipolar energy, hemoclips, or suture (**FIG. 9.16**).



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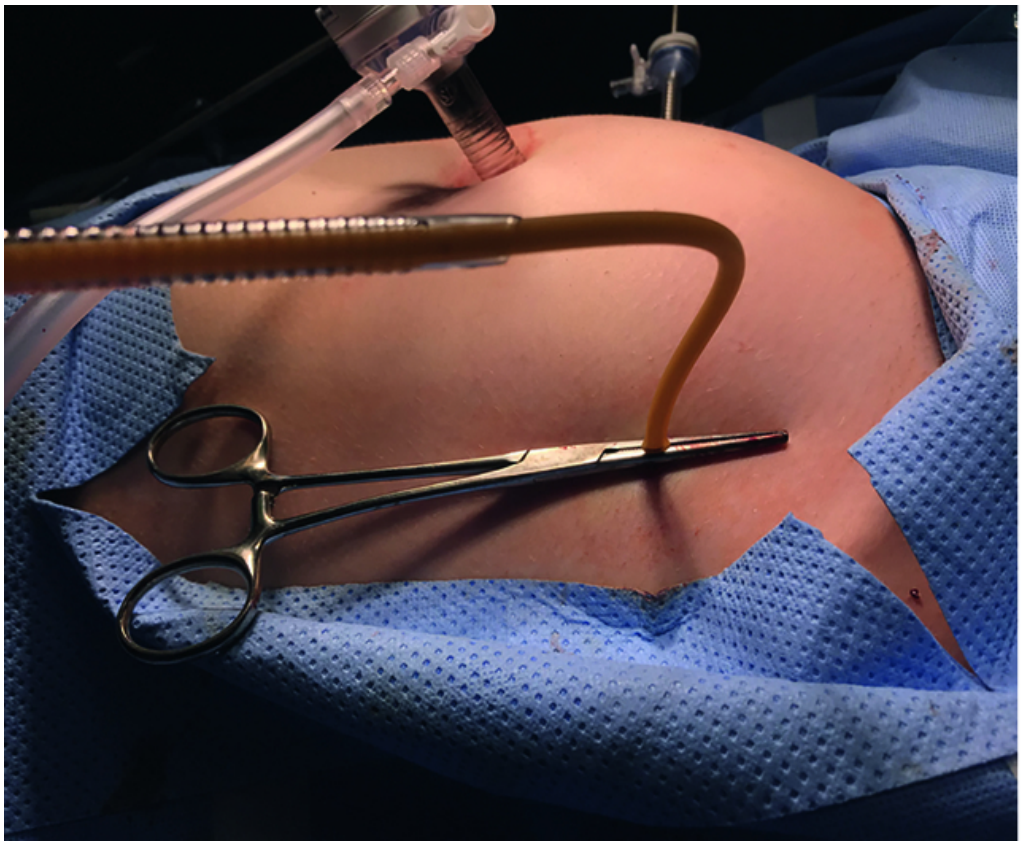


**FIGURE 9.16** Use of a Foley balloon to tamponade bleeding from an inferior epigastric artery. **A.** View from the abdominal cavity. The bulb is firmly applied to the abdominal wall. **B.** Tension is placed externally by pulling the Foley taught and clamping it against the abdominal wall.

## Urinary Tract

Injury to the bladder and ureters occur most commonly during hysterectomy, oophorectomy, resection of endometriosis implants, and pelvic support procedures. The incidence of injury to the urinary tract ranges between 0.02% and 2%. The risk increases if there is pelvic adhesive disease, distorted anatomy, enlarged uterus or

adnexa, or a history of prior pelvic surgery. There are three locations where the ureter is most vulnerable during laparoscopic pelvic surgery: (1) as it crosses the pelvic brim near the infundibulopelvic ligament, (2) as it travels posterior to the uterine artery at its insertion into the cardinal ligament, and (3) at the anterolateral vaginal fornix as the ureter enters the bladder. The bladder is most likely to be injured during development of the vesicocervical/vesicovaginal space during hysterectomy, especially in patients with history of prior cesarean delivery.

Routine cystoscopy is a common practice during laparoscopic hysterectomy and may be considered during any laparoscopic surgery when the urinary tract is at increased risk of injury or suspected to have been injured. The anesthesiologist is asked to administer intravenous indigo carmine or sodium fluorescein, or the patient can be asked to take oral phenazopyridine preoperatively orally, to color the urinary stream, this will color urine seen intra-abdominally and at cystoscopy. Backfilling the bladder with normal saline, sterile milk, or dye-tinged saline will detect an incidental cystotomy. Prior to starting surgery the bladder can be backfilled with any of the above solutions to distinguish its borders, allow more precise dissection, and prevent injury. Repair of injuries to the urinary tract is discussed in Chapter 37.

# Gastrointestinal

Bowel injury is associated with the highest mortality of laparoscopic complications, especially undiagnosed injuries. Injury can occur during initial entry, at any time during the procedure from thermal burn or laceration, or postoperatively because of hernia (either internal or at a port site). Injury to the stomach can occur on insertion of Veress needle or trocar placement at Palmer point. The stomach should be decompressed with a nasogastric or orogastric tube prior to insertion in the left upper quadrant.

If a small bowel injury is suspected, the surgeon should run the bowel in a systematic fashion from the ligament of Treitz to the terminal ileum. Small injuries will not always be visible or leak bowel contents at initial injury. Suspected large bowel injuries should be

treated in a similar manner. Management of injuries is dependent on size, depth, and type of injury.

Serosal injuries of <5 mm can usually be oversewn. Full-thickness stomach injuries and full-thickness small bowel injuries should be repaired in two layers with a delayed absorbable suture. If the length of the laceration to the small bowel exceeds one-half the luminal diameter, then a segmental resection and reanastamosis should be performed. Thermal injuries will appear smaller than the actual tissue necrosis, and if not treated will result in a delayed perforation. These should be excised completely and closed in two layers or with segmental resection. See Chapter 38 on management of bowel injuries.

Port site hernia is rare and most commonly occurs at port sites that are ≥10 mm often where sites were extended for tissue extraction. Proper fascia closure, incorporating both layers, is essential but does not always prevent hernia formation. Strangulation due to herniation of bowel at laparoscopic incision sites is an emergency. Often the incision must be opened and liberally extended to reduce and run the bowel. Internal hernia or volvulus can be avoided by lysing any abdominal adhesions that are encountered at time of surgery.

# Nerve Injury

Abdominal wall nerve injury can occur by direct injury to the nerve at the time of skin incision or intra-abdominally during surgery. Nerve transection injuries are usually permanent and associated with the most morbidity. Other nerve injuries occur because of compression or stretch from patient positioning. Often, compression injuries from positioning will resolve with time and treatment with physical therapy if needed. A key strategy for reducing the risk of peripheral nerve injury is to limit the time the patient is in lithotomy and Trendelenburg positions.

The brachial plexus branches from C5-T1 roots, passes posterior to the clavicle, and over the first rib. The upper extremity nerves and brachial plexus are at risk when patients are placed in steep Trendelenburg and pressure is placed on the arm while tucked or

untucked. Shoulder braces, if placed too far medially, apply direct pressure on the plexus. There is also risk of injury if the arms are left out at an angle >90° abduction, which causes stretch on the brachial plexus resulting in upper arm weakness, Erb palsy, or Klumpke paralysis. Injury to the ulnar nerve or radial nerve of the arm can occur with direct pressure over the humerus or medial epicondyle of the elbow usually at risk when arms are tucked. Proper tucking and padding of upper extremities are also extremely important. See Chapter 5 on safe positioning.

The femoral nerve branches from L2-L4 roots, exits the abdomen lateral to the psoas, and runs inferior to the inguinal ligament as it descends into the leg. It can be injured by placing the patient in excessive hip flexion and abduction. Femoral nerve injury results in weakness of hip flexion. Peroneal nerve injury is also almost always due to positioning. The peroneal nerve, a branch of the sciatic nerve, runs along the lateral side of the popliteal fossa and inferiorly next to the fibular head. Pressure on the fibular head with the stirrup or stretching while in lithotomy can result in peroneal neuropathy, which is numbness of the dorsal foot and foot drop.

Obturator nerve injury usually occurs as direct injury during radical pelvic surgery, lymphadenectomy, or prolapse repair. It results in weakness in hip adduction and medial thigh numbness. Sciatic nerve injury rare and is usually associated with prolonged lithotomy, especially in high lithotomy position (knee extension).

Iliohypogastric and ilioinguinal nerve injuries are reviewed in the section on trocar placement. These injuries can result in numbness or chronic pain that radiates along the area of innervation.

# SPECIAL POPULATIONS

## Pediatric Patients

Gynecologic surgeons are often consulted for pediatric and adolescent patients for a condition that may require a laparoscopy. There are several considerations in this patient population that should be considered in the planning and execution of laparoscopic surgery. First, these patients are often smaller, shorter, and have

less abdominal wall adiposity. Thus, operating room setup must accommodate their size. Also, shorter trocar lengths may be more appropriate. Typically, a lower insufflating pressure (≤12 mm Hg) is better tolerated in this patient population. Often adolescents will have increased fascial tension of the abdominal wall and required vigorous entry force. This increased force, combined with less adiposity and a shorter torso length, may increase risk of abdominal injury. The surgeon should be mindful and use open entry technique if concerned.

The surgeon should also consider that the reproductive anatomy in a pediatric or adolescent patient is different than a fully mature female: the cervix comprises most of the uterine length, the ovaries reside in a more superior location before puberty, and the hymen may still be mostly intact. Vaginal exam should be avoided when possible. Alternatives include a rectal exam or vaginoscopy. Pediatric size Foley catheters should be chosen.

Accessory trocars should be limited to 3- and 5-mm sizes. Fascial closure is recommended for all pediatric trocar sites. See Chapter 43 for other guidelines for treatment of pediatric patients.

# Obese Patients

Gynecologic surgeons must adapt their techniques to provide excellent care while still considering the challenges that surgery in the obese patient brings. There are obvious benefits of laparoscopy (as opposed to laparotomy) in this patient population. The first consideration is the need for adequate equipment for safe support of the patient. Bariatric beds should be available if needed for exceptionally obese patients. Stirrups that allow a larger calf diameter may be necessary. Arm extenders and/or sleds can be attached to the bed for arm support if patient width extends beyond the bed dimensions. Extra operating time should be allotted for patient positioning and a “tilt test” to assure the patient can be adequately ventilated in Trendelenburg position. Obese patients are at increased risk of neuropathy and compression injuries from positioning, thus ample padding should be used.

While planning entry point and accessory trocar placement, it may be helpful to retract a redundant panniculus inferiorly: Ioban adhesive dressing can be placed between the abdomen and upper thighs drawing the pannus downward, towel clamps can be placed on the lower pannus and attached to saline bags, or a Foley balloon can be threaded through a lateral trocar and attached to a retractor holder. A potential benefit of panniculus retraction, in addition to moving the extra tissue away from the operative field, is the decrease in weight near the chest that may improve ventilation (**FIG. 9.17**).

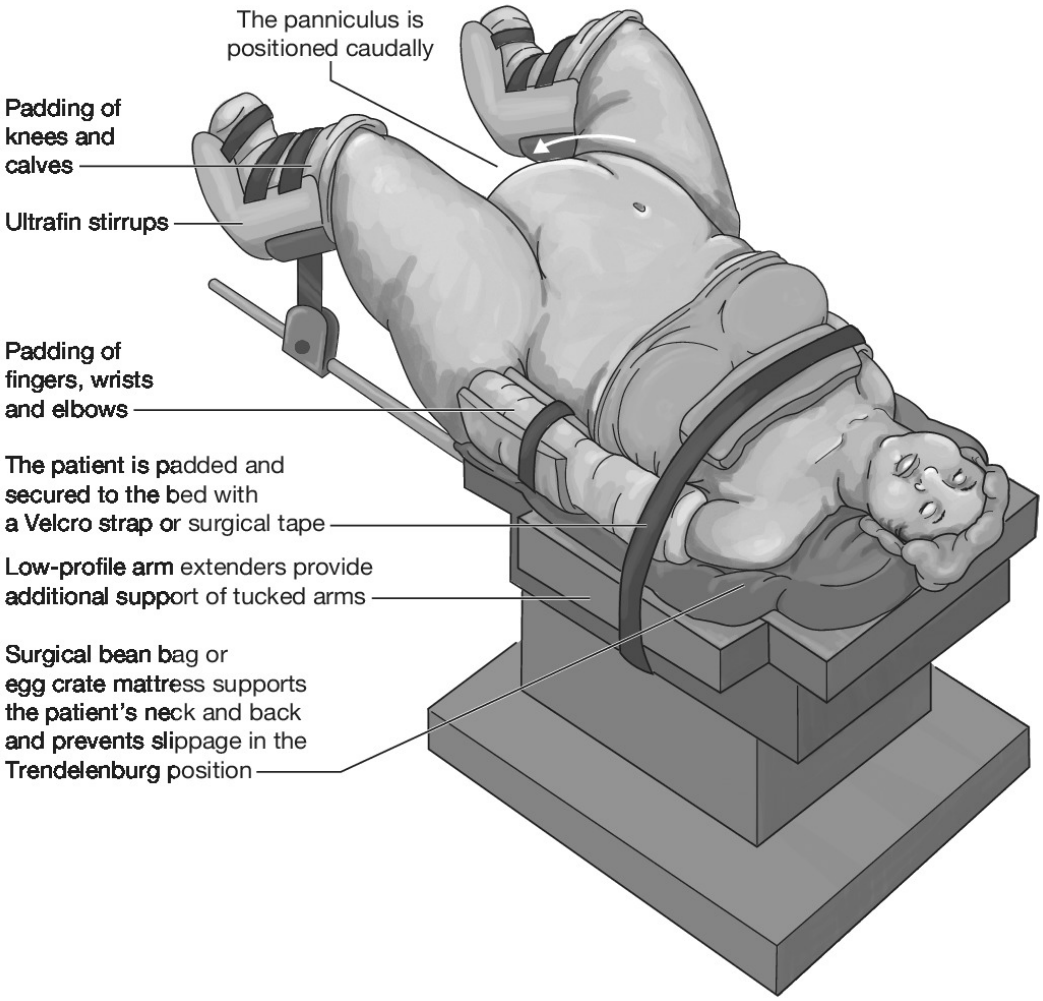


**FIGURE 9.17** Positioning of obese patient.

Bariatric trocars, which are 15 cm in length, should be available. However, with a correct entry angle at 90° to the abdominal wall, nonbariatric trocars are sufficient for entry into the peritoneal cavity. Once placed, these trocars have increased tendency to slide within their port track, likely due to less fascial tension and high adiposity. Trocars with a fixation device, such as balloon, wings, or external sutures, are available to maintain trocar positions.

# Pregnant Patients

Laparoscopy in a pregnant patient is not a common event but may be necessary for appendectomy, adnexal mass/torsion, or cholecystectomy and has the same risk as laparotomy. Surgical planning in this patient population is dependent on gestational age.

While there are data to support safe laparoscopic surgery at all gestational ages, in a nonemergent setting, it is advisable to plan surgical intervention between the 13th and 18th weeks of gestation and avoid the first trimester if possible since the patient is at highest risk of miscarriage during this time. In the third trimester, the larger gravid uterus poses the most risk as it must be avoided during entry and during surgery.

Most surgeons avoid Veress or direct entry in this patient population, regardless of gestational age, to lessen the risk of injury to the uterus on entry. Thus, open entry (Hasson technique) is often preferred. Without the ability to employ a uterine manipulator, atraumatic graspers and bed tilt must be judiciously utilized to expose the operative field. Accessory trocars are often placed more superiorly than in typical cases. Other pregnancy changes include increased vascularity and engorgement and pelvic veins with lower venous resistance; thus, care should be taken to avoid using sharp instruments or applying significant force against the uterus or sidewall structures.

Patients should be positioned in left lateral decubitus to minimize compression on the vena cava while undergoing surgery. Additionally, the intra-abdominal pressure from the pneumoperitoneum should be only as high as necessary for exposure. Most pregnant patients can tolerate insufflation pressure

of 10-15 mm Hg; however, many surgeons recommend maintaining a pressure of 12 mm Hg or less.

Fetal heart tones should be assessed and documented prior to and after surgery. Pregnant patients are at increased risk of DVT and prophylaxis with sequential compression devices should be utilized. The routine use of tocolytics is not supported (**FIG. 9.18**).

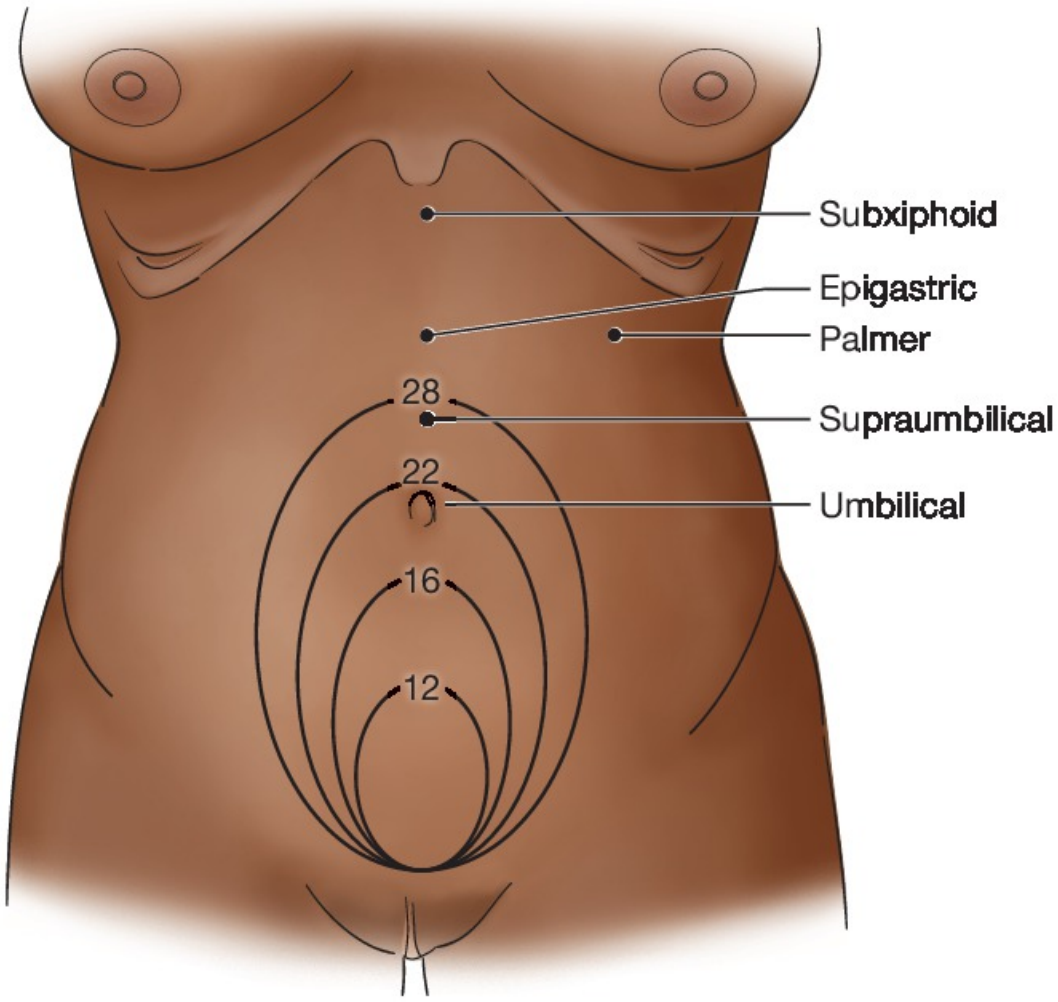


**FIGURE 9.18** Location of gravid uterus in relationship to umbilicus.

## Geriatric Patients

Laparoscopy has been shown to be safe in an aging population and has no added risk over laparotomy in most circumstances, but there are several considerations for this surgical approach in the elderly. The effects of carbon dioxide as a distention agent are more pronounced in an elderly patient, because of decreased cardiopulmonary reserve. Thus, it is advised that pneumoperitoneum pressures be maintained at lower levels (8-12 mm Hg if possible) to reduce risk in patients with existing comorbidities.

The effects of prolonged Trendelenburg are also greater in this population and can result in facial and head edema, gastroesophageal reflux, aspiration, and decreased pulmonary compliance. This patient group would benefit from periodic “breaks” from Trendelenburg position at regular intervals.

Tissue fragility and delayed wound healing are other considerations in the geriatric population. The surgeon should consider this while manipulating tissue and when providing postoperative instructions regarding resumption of normal activities, especially intercourse if there is a healing vaginal incision.

## KEY POINTS

- Laparoscopic surgery is a unique surgical approach to pelvic disease previously requiring laparotomy and has its own risks, challenges, and need for unique technical skills.
- Laparoscopy can be used as a diagnostic tool for many patient symptoms, including pelvic pain and infertility.
- Careful selection of patients, equipment setup, and procedure type are important to minimize injury.
- Laparoscopic surgeons should be well trained in electrosurgery, know pelvic anatomy, and the physiologic effects of pneumoperitoneum and Trendelenburg positioning.
- Laparoscopic surgeons should be aware of all potential complications related to laparoscopic surgery and understand the ways to treat or prevent those complications.

- Some patient populations undergoing laparoscopic surgery may require an adjustment of technique or approach to minimize risk of harm, accommodate body habitus, or comorbidities.

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# CHAPTER 10

# PRINCIPLES OF ROBOTIC SURGERY

Arnold P. Advincula and Sierra J. Seaman

**Equipment**
Surgeon Console
Patient-Side Cart
EndoWrist Instruments
Vision System
**Port Placement and Docking**
**Integrated High-Fidelity Simulator**
**Tissue Extraction and Closure**
**Role of Robotics in Gynecology**
Suture-Dependent Procedures
Procedures Requiring Fine Dissection
Large Patients and Pathology
**Conclusion**

The minimally invasive approach to surgery has become widely accepted as the standard of surgical care in the United States. There are numerous innovations that have been integral to this evolution including one disruptive technology in particular: robotics. Viewed by most as an evolution of conventional laparoscopy, robotic surgery

features articulation as opposed to rigid instrumentation, three-dimensional (3D) imaging, and improved ergonomics for surgeon comfort. Each of these features plays a key role in the paradigm shift seen with robotics as a surgical tool. The combination of wristed instruments and enhanced depth perception offers a potential level of precision and dexterity that provides unparalleled advantages when performing procedures that incorporate complex surgical tasks such as suturing and fine dissection. The improved ergonomics address surgeon comfort, a critical but often overlooked issue that plays an important role in patient safety and surgeon longevity.

Collectively, these features of robotic surgery enable surgeons to overcome some of the limitations of conventional laparoscopy such as counterintuitive hand movements, two-dimensional visualization, and a limited range of motion of instrumentation within the operative field. Robotic surgery is also associated with a shorter learning curve when compared to conventional laparoscopy. Limitations cited with the use of robotic surgery include the absence of haptic (tactile) feedback, the remote location of the operating surgeon, and the cost, which continues to be a point of major controversy and debate.

Although newer surgical robots have been introduced into the market since the advent of robotic surgery in the early 2000s, only one device, the da Vinci Surgical System (Intuitive, Sunnyvale, CA), has been utilized extensively in gynecologic surgery. The components, setup, and requisite instrumentation will be discussed in detail along with the integration of virtual and augmented reality simulation.

# EQUIPMENT

The da Vinci Surgical System has four main components:

1. Surgeon console
2. Patient-side cart
3. EndoWrist Instruments
4. Vision system

# Surgeon Console

Often referred to as the workstation or cockpit, the console is where the surgeon sits to perform robot-assisted laparoscopic surgery while viewing a high-definition three-dimensional image of the operative field. When seated, the surgeon grasps a pair of master controls with his/her fingers allowing wrists and elbows to be naturally positioned as if performing open surgery. Each movement of the surgeon's fingers, wrist, and hand is translated into precise and real-time movements of the surgical instruments attached to the patient-side cart. Motion scaling adjustments, the converesion of larger movements to smaller movements in the operative field, allow for further refinement by dampening or amplifying movements. The console includes a built-in two-way microphone and speaker system that facilitates clear and efficient communication to the bedside assistant. An option of integrating a second console allows for two surgeons to simultaneously control the robotic arms with attached instruments in either a teaching or synergistic relationship.

Also positioned within the surgeon console are foot pedals that perform a series of functions including activation of various energy sources (monopolar and bipolar radiofrequency currents) and switching between operative arms and camera movement. A readily accessible touch pad allows for customization of robotic settings along with adjustments that optimize surgeon ergonomics (**FIG. 10.1**).

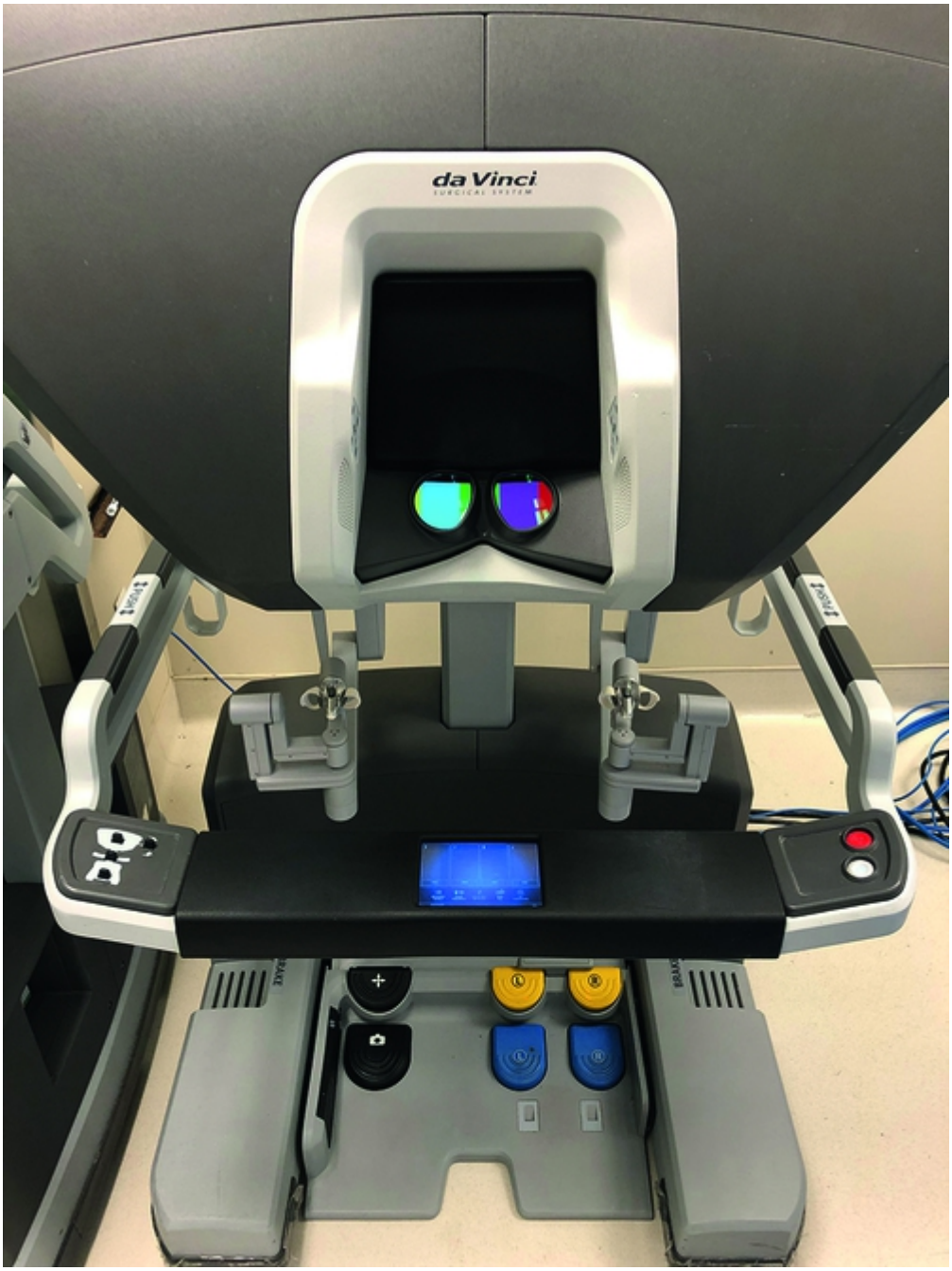


**FIGURE 10.1** Surgeon console with stereoscopic viewer, master controls, and foot pedals.

## Patient-Side Cart

This is the component of the da Vinci Surgical System that attaches directly to the patient. The patient-side cart includes four robotic arms mounted to either a stationary column (Si System) or rotating boom (Xi System) that moves in response to the surgeon's commands at the console. Because the Si System platform will soon be phased out, this chapter will focus only on the Xi System. The robotic arms are anchored to the patient via robotic trocars during a process called "docking." The fourth robotic arm is not necessary to perform either setup and based on surgeon preference can be stowed. Once anchored, EndoWrist instruments are attached to the robotic arms. The robotic arms and attached instruments are under the direct control of the surgeon. Depending on the platform being utilized, multiquadrant access to the surgical field can be obtained. Random movement of instruments or robotic arms is prevented by the robotic surgical safety system (**FIG. 10.2**).

1
2
3
4

**FIGURE 10.2** Patient-side cart with draped robotic arms (Xi platform).

## EndoWrist Instruments

These instruments are unique to the da Vinci Surgical System. They are designed to allow fluidity and dexterity with 7 degrees of motion (pitch, yaw, rotation, in and out, grasp, wristed pitch, and wristed yaw) and 90 degrees of articulation in contrast to traditional straight stick laparoscopy which only allows 3 degrees of motion and zero wristed articulation. They allow intuitive movements to be made with fingertip control while scaling down motion and reducing surgeon tremor. Each EndoWrist instrument is designed for a specific purpose: cutting, dissecting, clamping, coagulating, suturing, and manipulating tissue. Unique to the functioning of these instruments is the lack of tactile or haptic feedback. Although at times cited as a point of criticism, experienced robotic surgeons have learned to compensate for the lack of tactile feedback through the development of visual haptics based on clues obtained from tissue deflection and tensioning.

Instrument selection is quite extensive and equivalent to the many choices available on both conventional laparoscopic and open surgical platforms such as needle drivers, clip appliers, various graspers, a suction-irrigator, and a stapler (**FIG. 10.3**). **BOX 10.1** lists some of the many instruments available for use with the da Vinci Surgical System.

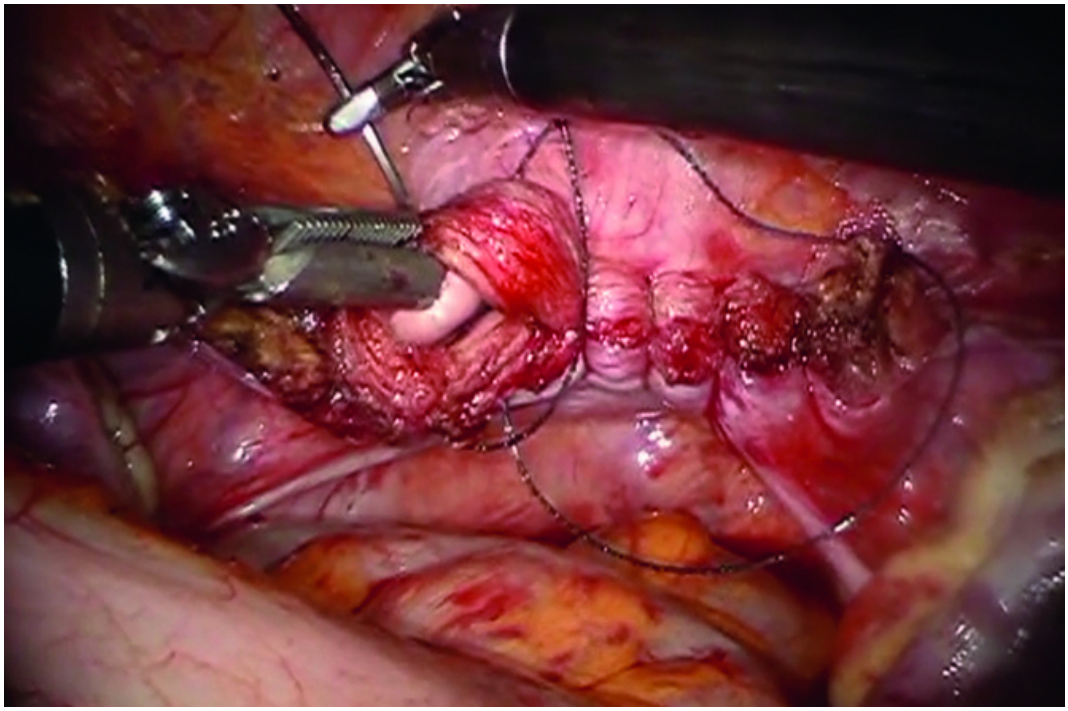

**FIGURE 10.3** Example of EndoWrist instruments (Cobra Grasper & Mega Suture Cut Needle Driver) used for vaginal cuff closure.

## BOX 10.1 INSTRUMENTS AVAILABLE FOR USE WITH da VINCI SURGICAL SYSTEM

**Monopolar Electrosurgery Instruments**

- Hot Shears
- Permanent Cautery Hook
- Permanent Cautery Spatula

**Bipolar Electrosurgery Instruments**

- Maryland Bipolar Forceps
- Fenestrated Bipolar Forceps
- Curved Bipolar Dissector
- Long Bipolar Grasper

- Micro Bipolar Forceps

**Vessel Sealer**
- SynchroSeal Vessel Sealer
- Vessel Sealer Extend

**Ultrasonic Energy Instruments**
- Harmonic ACE Curved Shears

## Vision System

The three-dimensional endoscope provides high-definition images of the operative field that is transmitted to the surgeon console. The heart of the vision system is housed on a rolling cart with a built-in monitor incorporating touch panel capabilities. Advanced features such as telestration and fluorescence imaging are also available on the vision system. The fluorescence imaging mode called Firefly provides real-time visualization and assessment of blood vessels, lymphatic channels, and tissue perfusion after administration of indocyanine green dye (ICG). The use of fluorescent-guided technology is applicable to endometriosis resection and oncologic staging using sentinel node identification.

# POSITIONING, PORT PLACEMENT AND DOCKING

Patient positioning is one of the most important components of robotic surgery because, after docking is complete, to make any correction to patient positioning requires undocking the patient side cart, moving the patient, then redocking the robot, which is time consuming. More recently, the Xi System can synchronize movement with an optional specialized table (Trumpf Medical/Hillrom, Ontario, Canada) while the robotic surgical system is attached to the patient, compensating for this caveat. Similar to conventional laparoscopy, the patient is positioned in low dorsal lithotomy in Allen Yellofins stirrups (Allen Medical Systems, Acton,

MA). To optimally position patients, extremities should be appropriately padded, and extreme joint flexion, extension, and abduction are avoided to prevent neuropathic injuries. Antiskid measures should be used to secure the patient to prevent sliding while in Trendelenburg (**FIGURE 10.4**).

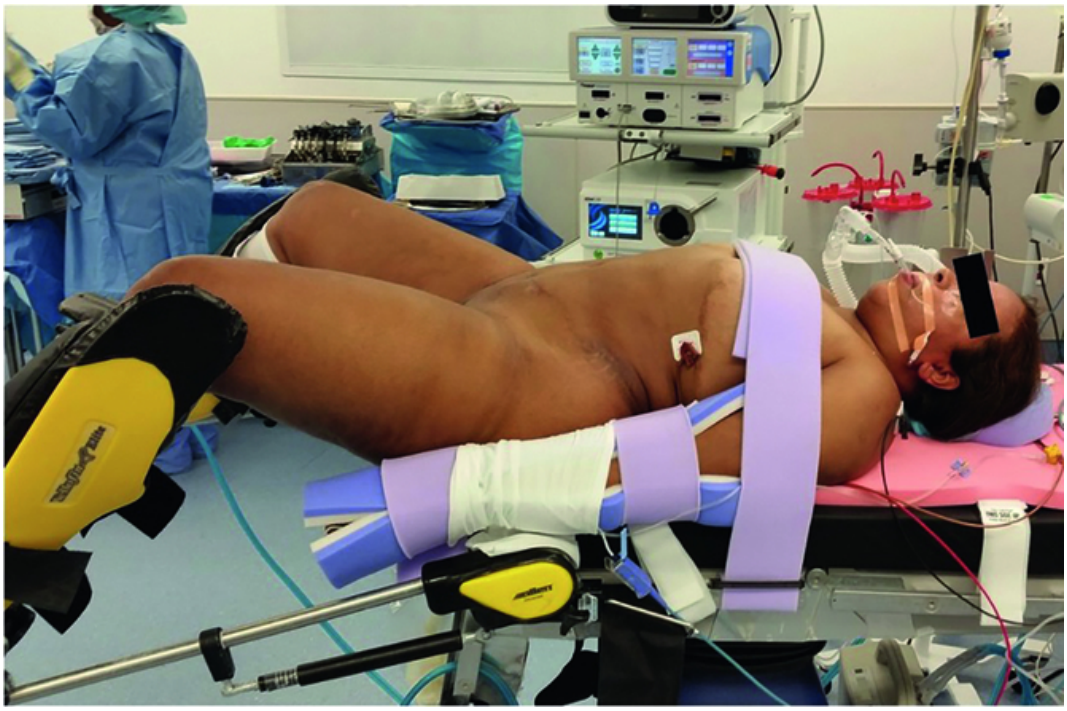

**FIGURE 10.4** Three-arm robotic trocar placement (da Vinci Si or Xi). A, assistant trocar; 1, robotic arm 1; 2, robotic arm 2; 3, robotic arm 3.

After the patient is anesthetized and safely positioned, trocars are placed. Although there is much variation as to preferred sites for trocar placement, a streamlined and reproducible process advocated by the authors is shown. After instillation of 2 mL of 0.25% Marcaine, a Veress needle is inserted, usually at the umbilicus. Pneumoperitoneum is established to 20 mm Hg. A 5- or 8-mm assistant trocar (A) is then placed under direct visual guidance with a

5-mm, 0° laparoscope at Palmer's Point along the midclavicular line, 2-3 cm or more below the costal margin. With the assistant trocar in place, adequate Trendelenburg tilt is obtained. The remaining 8- or 12-mm robotic trocars are then placed under laparoscopic guidance.

Strategic placement of the robotic trocars is critical to optimize proper functioning of the robotic arms and EndoWrist instruments and to avoid external arm collisions once docking is complete. It is important to have a distance of at least 8-10 cm between all trocars. For traditional three-arm robotic surgery, two robotic trocars are placed in the left and right side of the abdomen at the level of the umbilicus and just medial to a vertical line drawn from the anterior superior iliac crest. These lateral trocars can be placed 1-2 cm caudal or cephalad to the level of the umbilicus for smaller or larger pathology, respectively. During traditional four-arm robotic surgery, a fourth robotic trocar is placed in the upper quadrant contralateral to the side of the assistant trocar. The umbilical port typically functions as the endoscope trocar (**FIG. 10.5**, **VIDEO 10.1**).

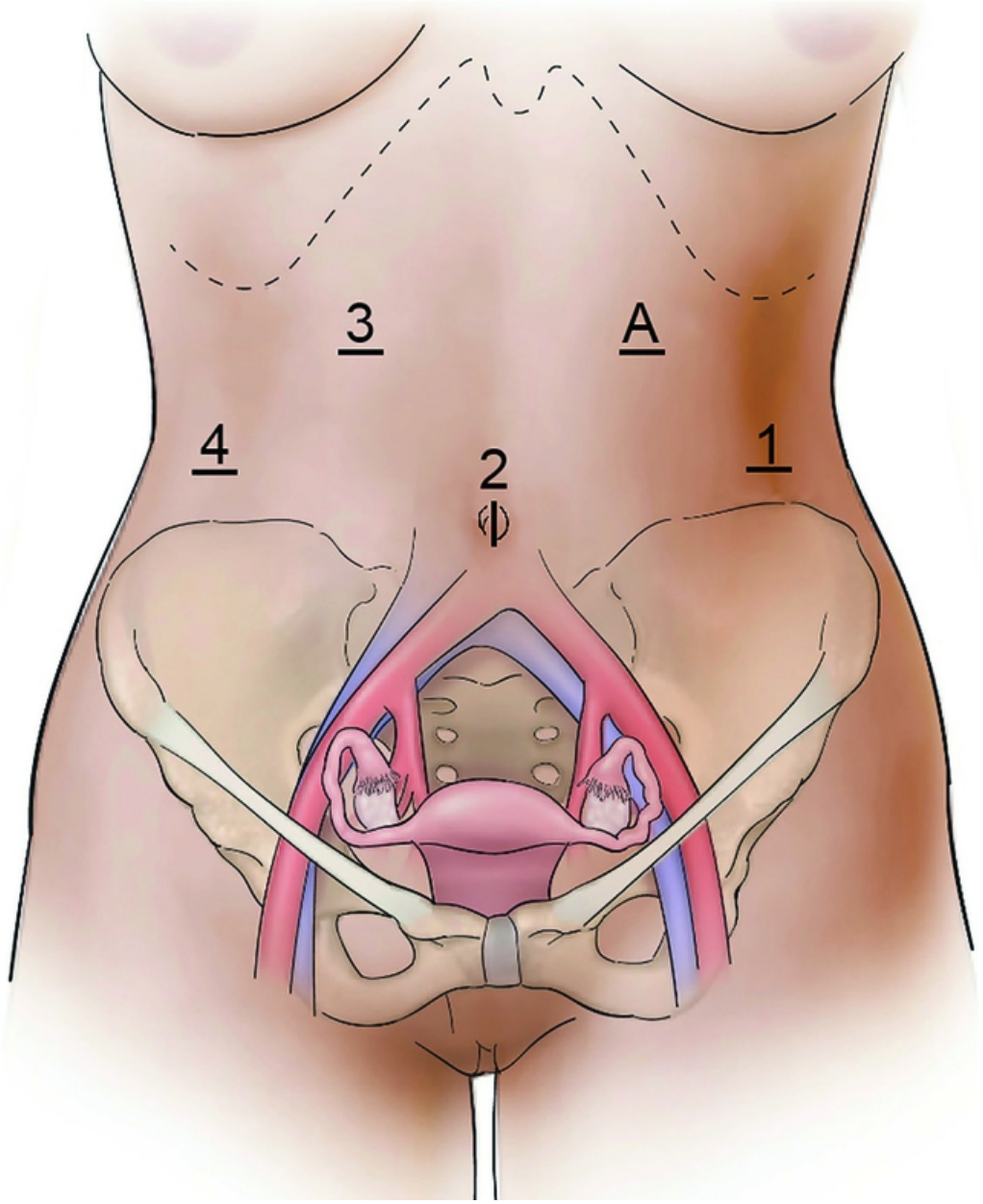


**FIGURE 10.5** Four-arm robotic port placement. A, assistant trocar; 1, robotic arm 1; 2, robotic arm 2; 3, robotic arm 3; 4, robotic arm 4.

After trocar placement is completed, pneumoperitoneum pressure is decreased to 15 mm Hg and the patient-side cart is moved by

surgical staff to the patient bedside to begin the docking process. Docking is the process of attaching the robotic arms of the patient-side cart to the specialized robotic trocars inserted in the patient. For efficiency, the patient-side cart is docked perpendicular to either the patient's right or left mid-torso to allow unobstructed extracorporeal access to the perineum during gynecologic procedures if traditional multiport triangulated robotic surgery is performed. The authors recommend docking the side cart on the side of the surgeon's handedness for optimal fourth arm usage (**FIG. 10.6**).

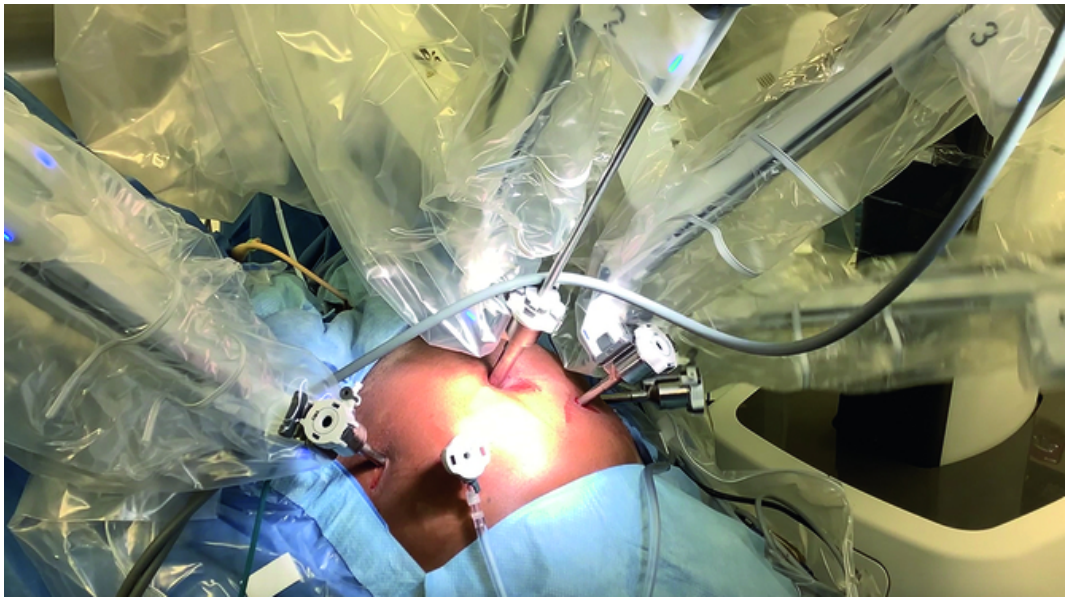

**FIGURE 10.6** Example of right-sided robotic docking.

The robotic arms are mounted on a boom from which they are deployed with the touch of a button built into an interface on the patient-side cart. This interface is easy to learn and features a guided walkthrough, voice assistance, and precise setup. An external laser targeting system ensures accurate placement and optimal positioning of the robotic arms, while a built-in endoscopic targeting system further enhances the height and rotation of the boom as well as location of the robotic arms. Once the arms are

correctly positioned over the patient, they can be guided to their associated port by grabbing the arm and then docking it using the rear clutch button and the forward-facing latch. Small adjustments can then be made to the spread and angles of the arms to optimize the pitch and yaw.

After securely docking the robotic arms, the robotic instruments can be inserted. After the camera is docked, it can be used to visually guide each instrument into place either directly or by using the hash mark cues on the visual monitor. After all instruments are in view, the surgeon takes over control at the console and the surgery can begin (**VIDEO 10.2**).

## INTEGRATED HIGH-FIDELITY SIMULATOR

A high-fidelity virtual reality robotic simulator, SimNow (Intuitive, Sunnyvale, CA) is available on the da Vinci Surgical System. The optional modular component with associated software is integrated into the actual surgeon console for enhanced realism. Surgical training is provided through the use of videos and system skills exercises. The simulator exercises range from basic to advanced skill levels allowing for the training of residents, fellows, and attending surgeons with varying baseline skill sets. Skill categories include EndoWrist manipulation, camera movement, needle control and driving, energy and dissection, system settings, and fourth arm integration. Prebuilt curricula are available along with the ability to customize the simulator experience to meet the specific needs of the user. Freestanding simulators, such as the FlexVR and RobotiX Mentor (Surgical Science, Goteborg, Sweden), are also available for training (**FIG. 10.7**).

**FIGURE 10.7** FlexVR training platform offering simulation to enhance robotic surgery skills.

Studies have demonstrated the predictive validity of a training protocol incorporating a robotic simulator to gain the necessary skills to perform robotic surgery in one study. Culligan was able to demonstrate translation of newly acquired robotic simulator skills to expert-level performance during live human surgery. Such evidence supports the utility of robotic simulation to shorten the learning curves of novice users.

## TISSUE EXTRACTION AND CLOSURE

There has been increasing need for a robotic approach to extract larger pathology in a minimally invasive fashion. The issue of tissue bagging and extraction has increased in importance especially

considering the controversy that began in 2014 surrounding power morcellation. For large specimens, this is a particularly challenging task. The process of tissue retrieval involves placing the tissue into an appropriate-sized specimen retrieval bag. Intracorporeal bagging is a skill unto its own and is explained in detail in **VIDEO 10.3** during which a containment bag is introduced through the umbilicus and the robotic instruments are used to place the tissue appropriately within the bag prior to extraction. Once the tissue is contained, the bag is typically brought up through the umbilicus or alternatively below through the vaginal cuff. The robot is then undocked for tissue extraction. An extracorporeal approach, known as ExCITE (Extracorporeal C-Incision Tissue Extraction) is one approach to specimen extraction. If a transabdominal approach is utilized, the umbilical trocar site is extended to 3 cm and a small disposable wound retractor is placed inside the specimen retrieval bag to facilitate retraction of the fascia and stabilization of the containment system (**FIGS. 10.8 and 10.9**). Then, using a number 11 blade scalpel, the specimen is "cored" in large-diameter strips and subsequently extracted, with care taken to not disrupt the containment system. Once tissue extraction is complete, the fascia of the extended umbilical trocar site is closed with an absorbable braided suture under direct visualization. In cases of transvaginal tissue extraction, the specimen is also contained and then brought out through the open vaginal cuff. Traditional vaginal retractors are placed inside the specimen retrieval bag and the tissue is extracted in a similar fashion as described above. Upon completion, the vaginal cuff can be closed manually from below or with the aide of the robot from above (**VIDEO 10.4**).

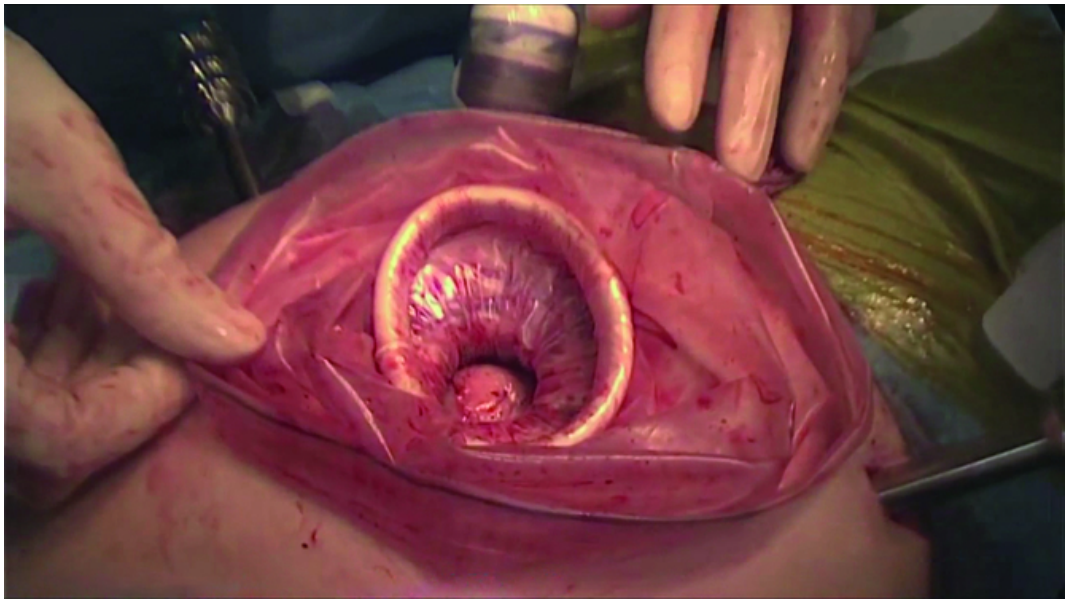

**FIGURE 10.8** Setup for ExCITE technique

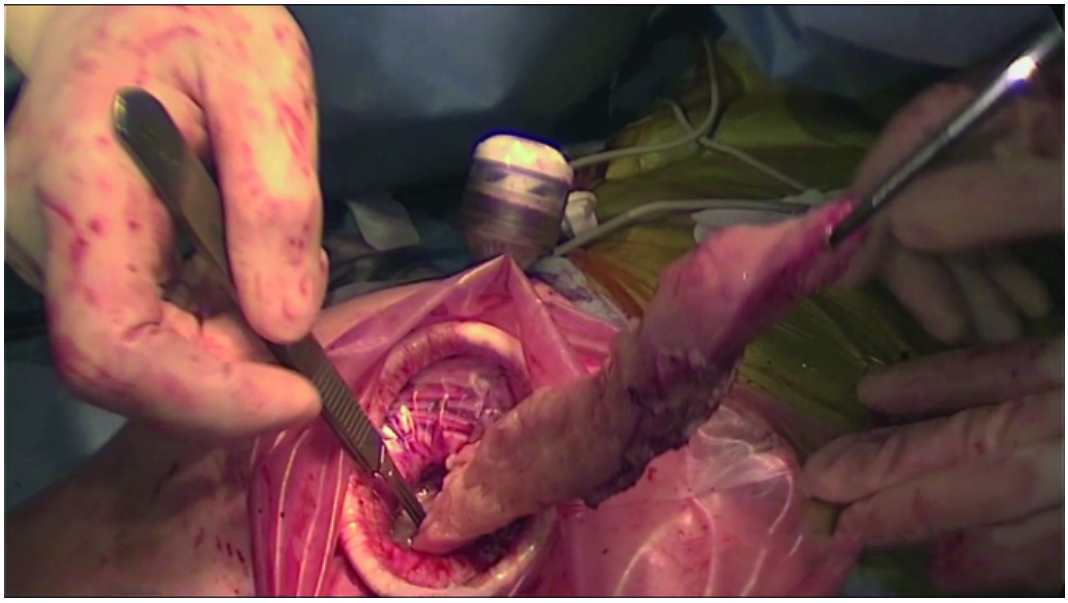

**FIGURE 10.9** Myoma extraction using the ExCITE technique.

The incidence of laparoscopic port site hernias ranges from 1% to 6%, and the risk is increased in ports that are 1 cm or greater. During

robotic surgery, trocars are 8 mm unless a 12-mm trocar is used to accommodate the robotic stapler, or a larger assistant trocar is needed. Any peritoneal access sites 1 cm or greater are closed with an absorbable braided suture. Use of laparoscopic port closure devices can facilitate fascial closure; however, traditional closure methods using curved needles are sufficient and more cost-effective.

# ROLE OF ROBOTICS IN GYNECOLOGY

Three broad categories of surgery are particularly well suited to a minimally invasive robotic approach. These include suture-dependent procedures (myomectomy, tubal reanastomosis, sacrocolpopexy), procedures requiring fine dissection (excision of deeply infiltrating endometriosis DIE and lymphadenectomy), and procedures involving large patients and/or pathology.

## Suture-Dependent Procedures

The 7 degrees of freedom and 90-degree wristed articulation of the EndoWrist instruments make the robot an excellent tool for performing suture-intensive procedures. *Myomectomy*, a common procedure performed for the surgical management of uterine fibroids in patients who desire uterine preservation or future fertility, is a suture intensive surgical procedure that benefits from robotic assistance. Laparoscopic myomectomy (LM) is now commonly performed and accepted as the “gold standard” approach. The technical challenges of conventional LM include enucleation of the fibroid along the correct dissection plane and performing a subsequent multilayered hysterotomy closure (**FIG. 10.10**). Use of robotic assistance for LM, coined robotic-assisted laparoscopic myomectomy (RALM), was introduced as an alternative approach to overcome the limitations of conventional LM. With the ability to control three instruments simultaneously and articulating wrists to aid both in dissection and needle throwing, RALM has become widely

accepted as a minimally invasive approach to fibroid surgery (**VIDEO 10.5**).

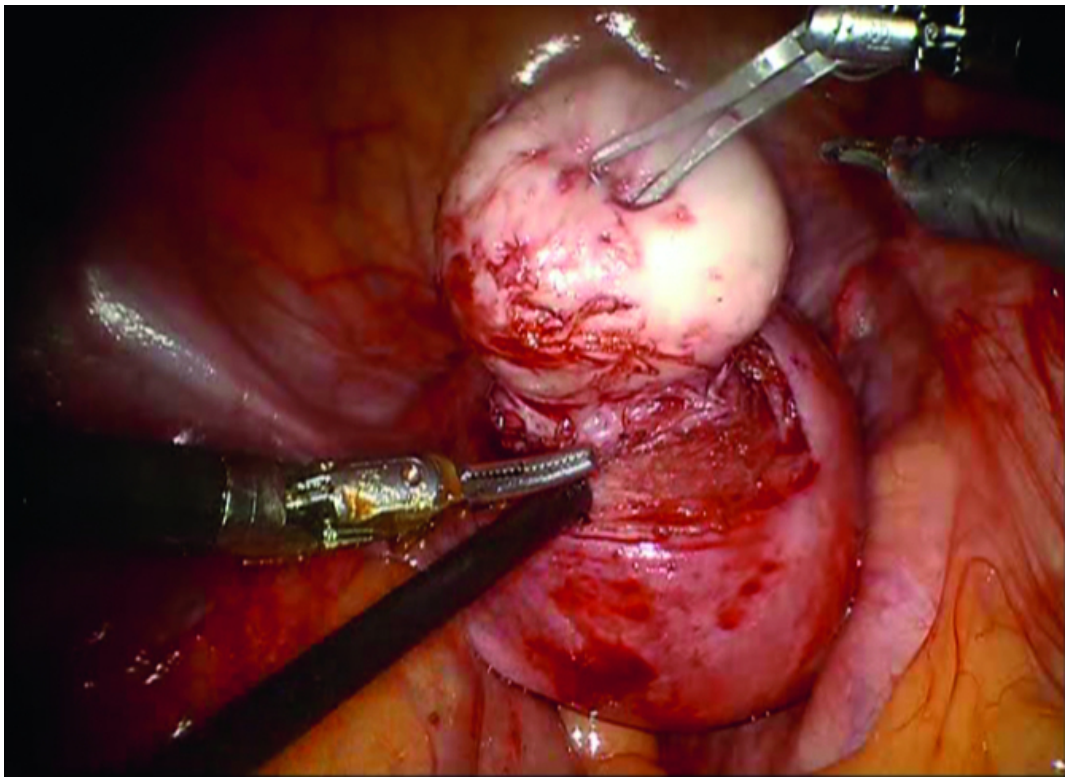

**FIGURE 10.10** Enucleation of intramural myoma.

Tubal reanastomosis is performed to restores tubal patency and enable conception after a previous tubal sterilization. It requires careful manipulation of the previously transected fallopian tubes with subsequent dissection of the separated proximal and distal segments followed by meticulous reanastomosis using very fine suture. Utilizing a robotic approach allows for enhanced depth perception with a magnified operative field along with tremor filtration, motion scaling, and use of wristed instruments to facilitate surgery (**FIG. 10.11**).

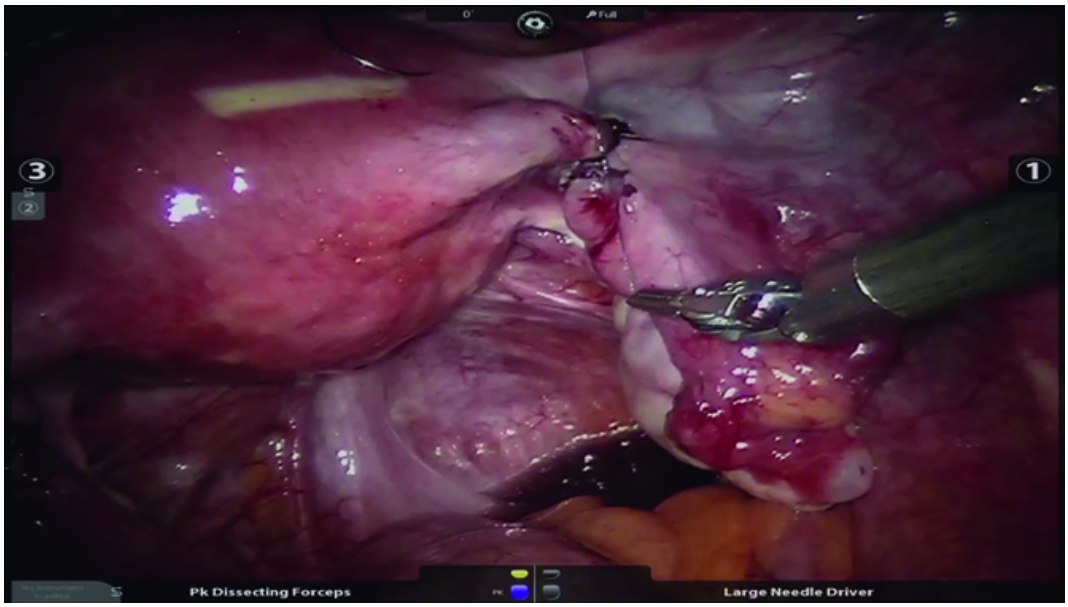


**FIGURE 10.11** Intracorporeal knot-tying during tubal reanastomoses. 1, robotic arm 1; 3, robotic arm 3.

Sacrocolpopexy is performed to repair pelvic prolapse and can be performed abdominally or laparoscopically. Global acceptance by urogynecologists had been limited due to its difficult technical aspects in particular the extensive suturing required for the placement of mesh. It is for these reasons that robotic-assisted sacrocolpopexy (RASC) evolved (**FIG. 10.12**).

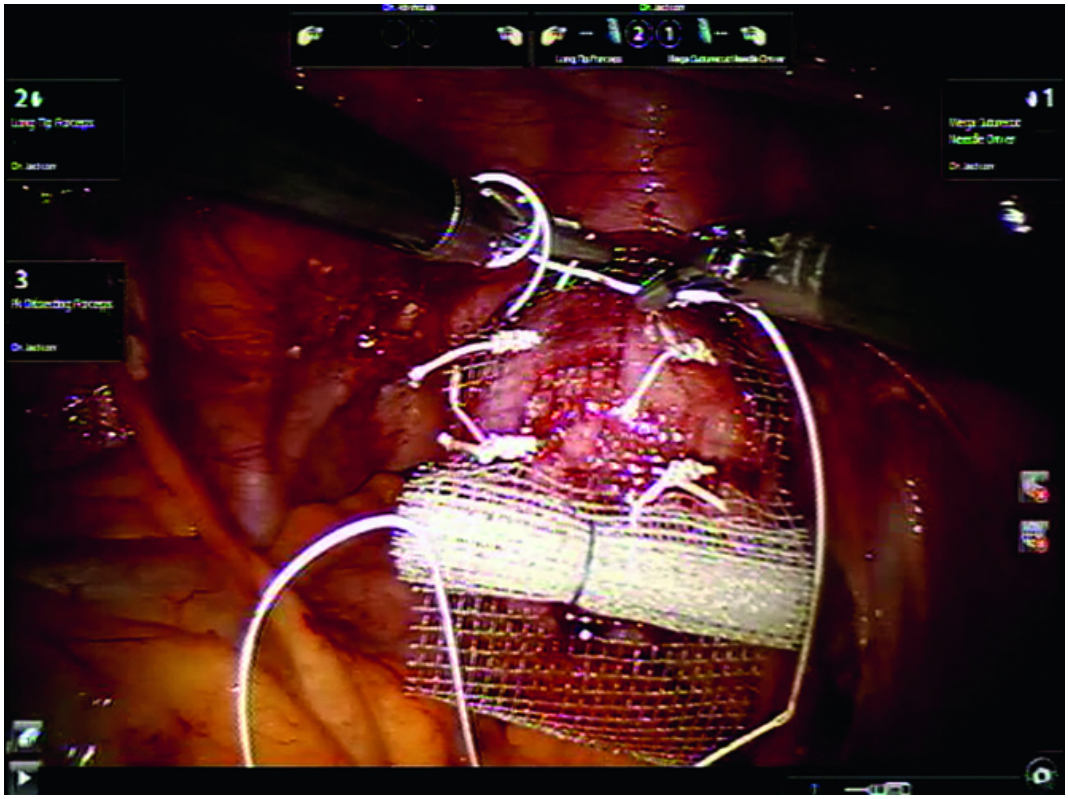

**FIGURE 10.12** RASC mesh fixation during sacrocolpopexy.

RASC is a safe, effective, and reliable method for treating apical prolapse; however, its benefit over conventional laparoscopy remains debatable. A 2015 meta-analysis concluded that the advantages of RASC complications and anatomical outcomes remain unclear. A 2016 meta-analysis acknowledged that the advantages of robotic surgery and its ability to “boost surgical capacities” but cautioned about the high cost of robotic surgery and emphasized the need to negotiate lower costs.

Transabdominal cerclage placement for treatment of cervical insufficiency is another example of a suture-dependent surgery well suited for robotics. A 5-mm Mersilene tape on a large blunt point needle is passed bilaterally in an anterior to posterior direction at the level of the internal os, medial to the uterine vessels. Absolute control of the needle is necessary for the critical step of passing the

needle. The wristed movement of the needle driver allows for a seamless atraumatic single pass (VIDEO 10.6).

## Procedures Requiring Fine Dissection

Gynecologic procedures requiring fine dissection benefit from the tremor filtration and motion downscaling built into the articulating instruments used with the robotic platform. Combined with improved imaging, these features enhance the surgeon's ability to manipulate the operative field as needed for identification and delineation of tissue planes. Examples of procedures that require fine dissection and benefit from a robotic approach are excision of deeply infiltrative endometriosis (DIE), lysis of extensive adhesive disease, and oncologic procedures requiring extensive and/or radical dissection such as lymphadenectomy.

DIE is a severe form of endometriosis, which is defined as lesions penetrating >5 mm underneath the peritoneum and found deep within the tissue or adjacent organ. These lesions can occur in the rectovaginal septum, rectum, sigmoid colon, bladder, and vagina. Optimal excision of DIE requires a thorough understanding of pelvic anatomy, an ability to identify tissue planes, and the skills and tools to perform very fine dissection. For reasons previously reviewed, DIE resection is well suited to a robotic surgical approach (FIG. 10.13). The only randomized controlled trial comparing a robotic approach to conventional laparoscopy found no difference in outcomes between approaches. Although the available literature consists of mostly case reports and retrospective studies, robotic-assisted laparoscopy is regarded as a safe, feasible, and effective route for surgical excision of DIE (VIDEO 10.7).

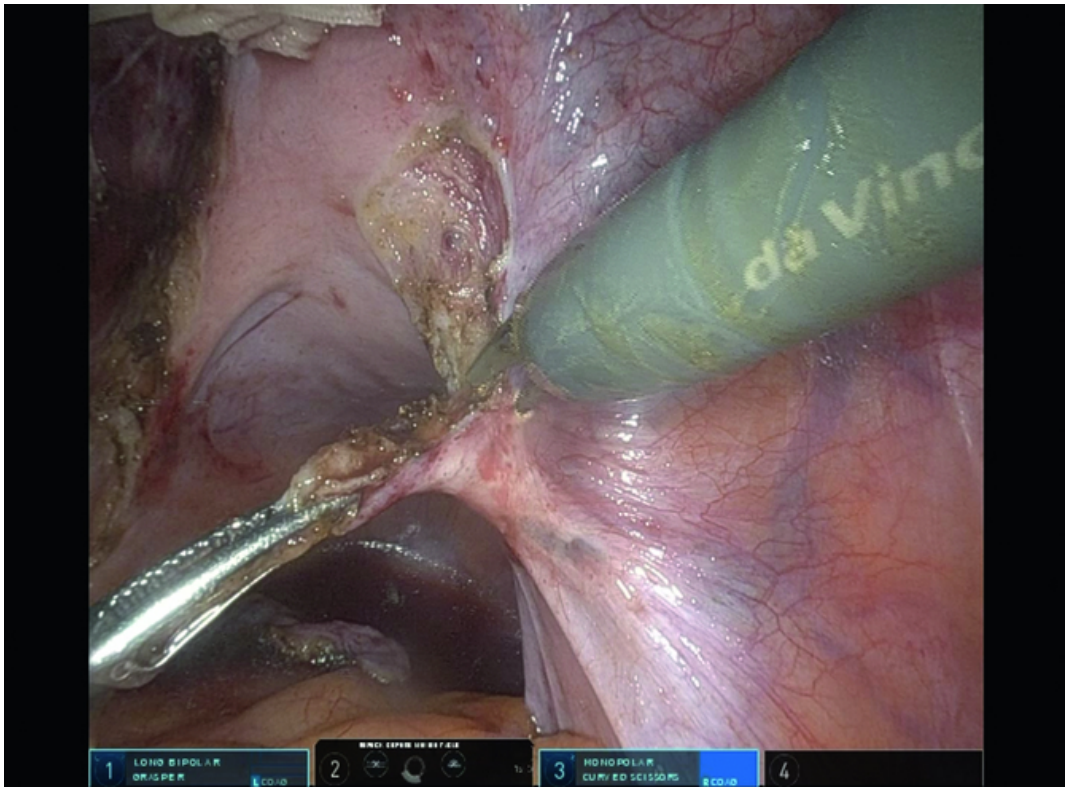


**FIGURE 10.13** Resection of deeply infiltrating endometriosis (DIE) involving right uterosacral ligament.

Lysis of extensive adhesions and oncologic procedures such as lymphadenectomy leverage the advantages of robotic surgery especially when it comes to its fine dissection capabilities. In the past, pelvic adhesions were considered a contraindication to laparoscopic surgery and a risk factor for conversion to laparotomy and postoperative readmissions. However, Chiu et al. reported decreased operative times and decreased blood loss during robotic hysterectomy compared to conventional laparoscopic hysterectomy when severe adhesive disease was present. The authors of this study attribute the relative ease of adhesiolysis to the increased dexterity offered by the wristed instruments, which facilitates dissection at difficult angles, as well as the ability to utilize the third robotic arm for countertraction.

A burgeoning application that combines the suturing and fine dissection benefits of robotics is cesarean scar niche or isthmocele repair. Treatment of symptomatic isthmocele includes hysteroscopic, transvaginal, laparoscopic, and robotic routes. While little comparative data exist in cases where there is minimal residual myometrial thickness in a fertility-seeking patient, it is our preference to utilize a robotic approach. This application is described in detail in VIDEO 10.8.

## Large Patients and Pathology

Regardless of whether laparoscopy is performed by conventional means or with robotic assistance, technical challenges and limitations exist with either approach. These limitations are magnified when the patient and/or the pathology being treated are large. A robotic approach allows the surgeon to perform hysterectomies on larger uteri when compared to conventional laparoscopy. Studies have shown a cost profile and operative time in favor of robotic hysterectomy for uteri >750 g (VIDEO 10.9).

Obesity is an epidemic in the United States and a major source of distress to surgeons as rates have continued to increase over the years. Obese patients are at higher surgical risk for poor wound healing, infection risk, and conversion to laparotomy. A minimally invasive surgical approach in obese patients is associated with improved postoperative outcomes. Use of the wristed instruments facilitates access to difficult angles and spaces, while use of the third robotic arm improves exposure by retracting redundant bowel and adipose tissue. Overall, robotic surgery offers a safe and feasible alternative to laparotomy and conventional laparoscopy when operating on obese patients and patients with large and complex pathology.

# CONCLUSION

Robotics brings advantages to surgery that impact patient outcomes and expand available treatment options. The various components have evolved through the years and center mostly on use of wristed

instrumentation, improved vision, and surgeon ergonomics. Another important aspect is integration of a high-fidelity simulation program to facilitate acquisition of the necessary skills. Once mastered, gynecologic surgeons can leverage robotic advantages to overcome limitations and obstacles associated with conventional laparoscopy.

## KEY POINTS

- Wristed instrumentation with tremor filtration motion scaling, three-dimensional imaging, and improved ergonomics are advantages of robotic surgery.
- Strategic trocar placement and docking are critical to the success of the robotic approach.
- High-fidelity simulation exercises enhance robotic skill development.
- The robotic platform facilitates surgical management of large pathology. Extraction methods are available to remove large specimens.

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# SECTION III

# Postoperative Care


## 11 Postoperative Care of the Gynecologic Patient
Rajiv B. Gala

## 12 Postoperative Infections in Gynecologic Surgery
Anna Powell

## 13 Critical Care of the Gynecologic Patient
Duncan J. McLean and William M. Hart

# CHAPTER 11

# POSTOPERATIVE CARE OF THE GYNECOLOGIC PATIENT

Rajiv B. Gala

**Immediate Postoperative Care**
Pain Control
Diet
Fluids and Electrolytes
Foley Management
**Intermediate Postoperative Care**
Postoperative Delirium
Cardiac Complications
Pulmonary Complications
Gastrointestinal Complications
Renal Complications and Electrolyte Imbalances
Postoperative Transfusion
Wound Care
Venous Thromboembolism

Postoperative complications are the most important factors in defining the short-term outcomes of gynecologic surgery. Postoperative morbidity can be minimized by adequate preoperative planning (with risk assessment) and diligent postoperative care. The

preoperative preparation of the surgical patient is reviewed elsewhere in the text (including Chapter 2).

# IMMEDIATE POSTOPERATIVE CARE

Postoperative treatment orders are necessary to direct postoperative care and should cover the following: vital signs, respiratory care, pain control, diet, and labs. Blood pressure, pulse, and respiration and oxygen saturations are closely monitored in the immediate postop period. In the postanesthesia care unit, the frequency of these vital sign measurements depends upon the complexity of the operation and the stability of the patient. All significant deviations in vital signs should be communicated with the anesthesiologist and surgeon.

The intraoperative anesthesia record helps document all the administered fluids (crystalloid, colloid, and any blood products) and operative output, including blood loss and urine output. Continuation of the record throughout the postoperative period will aid with the proper assessment of hydration and necessary postoperative fluid replacement. Once the indwelling Foley catheter is removed, the surgeon should be notified if the patient is unable to void within 4-6 hours.

Aggressive pulmonary expansion using incentive spirometer and deep breathing exercises can reduce the relative risk of pulmonary complications by up to 50%.

Early ambulation prevents atelectasis and the pooling of secretions as an upright position distributes blood flow and minimizes shunting. Patients should be encouraged to dangle their legs off the side of the bed, sit in a chair, or walk on postoperative day 0.

## Pain Control

Postoperative pain management, like all surgical care, begins with the preoperative assessment. Patients with preexisting pain syndromes and patients with a history of opioid use may have a high tolerance for opioid analgesics. Nevertheless, different patients can

experience different levels of postoperative pain even after similar procedures. The factors responsible for these differences include duration of surgery, type of incision, and magnitude of intraoperative retraction. Gentle handling of tissues, minimally invasive approaches, and good muscle relaxation help lessen the severity of postoperative pain. The anxiety and emotional component of the patient's pain perception can be reset through appropriate preoperative expectation setting.

Prevention of postoperative pain is important for reasons beyond patient comfort. Effective pain control may improve the outcome of surgery itself. Postoperative pain can lead to the release of catecholamines and other stress hormones that causes vasospasm and hypertension, which may contribute to complications such as stroke, myocardial infarction (MI), and bleeding. Poor pain control leads to decreased satisfaction with care, prolonged recovery time, increased use of health care resources, and increased costs.

The physiology of postoperative pain involves transmission of pain impulses via splanchnic afferent fibers to the central nervous system, where they initiate spinal, brain stem, and cortical reflexes. Skeletal muscle spasm, vasospasm, and gastrointestinal (GI) ileus result from stimulation of neurons in the anterior horn. Brain stem responses to pain include alterations in blood pressure, ventilation, and endocrine function. Voluntary movements and psychological changes, such as fear and anxiety, are cortical responses. These emotional responses lower the threshold for pain perception and perpetuate the pain experience.

The American Pain Society, with input from the American Society of Anesthesiology (ASA), published an evidence-based guideline on the management of postoperative pain. Multimodal analgesia is recommended for the treatment of postoperative pain in children and adults. The additive effects of targeting different mechanisms of action throughout the nervous system are more effective than single modality interventions. Multimodal options for pain management include nonopioid and opiate-based medications (**TABLE 11.1**).

# TABLE 11.1
# Oral and Parenteral Nonopioid and Narcotic Analgesics for the Treatment of Pain

| GENERIC NAME | ROUTE[a] | STARTING DOSE (mg) | EQUIANALGESIC DOSAGE (mg)[b] | ONSET OF ACTION (minutes) | PEAK EFFECT (hours) | DURATION OF ACTION (hours) |
|---|---|---|---|---|---|---|
| **Nonopioid Analgesics** | | | | | | |
| Acetaminophen | PO/IV | 100-325 mg q4-6h (4000 mg/24 h max) | | 30-45 | 0.5-1 | 4-6 |
| Ibuprofen | PO/IV | 400-600 mg q6h (2400 mg/24 h max) | | 30-60 | unknown | 4-6 |
| Naproxen sodium | PO | 550 mg q12h (1100 mg/24 h max) | | 30-60 | unknown | 7-12 |
| **Narcotic Analgesics** | | | | | | |
| Morphine | IV/IM | | 10 | | | |
| | PO | 15 | 30 | 15-60 | 1 | 3-6 |
| Hydromorphone | IV/IM | | 2 | | | |
| | PO | 4 | 5 | 30 | 0.5-1 | 3-4 |
| Fentanyl | IV/IM | | 0.1 | | | |
| Hydrocodone | PO | 5-10 | 25 | 10-30 | 0.5-1 | 4-6 |
| Oxycodone (IR) | PO | 5-10 | 10-15 | 15 | 1-2 | 3-4 |
| Tramadol | PO | 50-100 | 250 | 60 | 2-3 | 6 |
| Codeine | PO | 30 | 180 | 15-30 | 0.5-1 | 4-6 |

[a]Intramuscular (IM); intravenous (IV); oral (PO).

[b]Equianalgesic dosage conversions are based on a total daily (24 h) opioid dose of morphine 10 mg IV/IM.
Reference: https://clincalc.com/Opioids/

# *Nonopioid Treatment Options*

The two major classes of nonopioid therapies are acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs). Multimodal pain control postoperatively using a combination of intravenous (IV) NSAIDs and acetaminophen can enhance analgesia, lower narcotic needs, and decrease the incidence of postoperative nausea and vomiting by as much as 30%. The American Pain Society suggests incorporating these nonopioid (and any additional nonpharmacologic) therapies around the clock as part of a postoperative analgesia regimen. Acetaminophen is hepatotoxic in high doses, and the total daily dose should not exceed 4000 mg/d.

NSAIDs can be nephrotoxic and should be used with caution in patients with chronic kidney disease.

## *Opioid Treatment Options*

The management of moderate to severe pain typically includes the administration of opioids. Most evidence suggests that oral and parenteral modes of administration are equally effective. The American Pain Society recommends the use of IV patient-controlled analgesia when the parenteral route is needed.

The three most commonly prescribed parenteral opioids are morphine, hydromorphone, and fentanyl. Morphine is prescribed most frequently following gynecologic surgery and is a potent μ-opiate receptor agonist, which leads to the euphoria, respiratory depression, and decreased GI motility seen. Peak activity is seen within 20 minutes of IV administration and lasts for 3-4 hours. Pruritus is a common side effect and can be managed with antihistamines. Hydromorphone (Dilaudid) is a semisynthetic analogue of morphine. It is available for delivery by multiple routes, including oral, intramuscular, IV, rectal, and subcutaneous. Hydromorphone achieves its peak effect about 15 minutes after IV administration, and its effects last 3-4 hours. Hydromorphone is a suitable patient-controlled analgesia alternative in patients with a morphine allergy. Fentanyl, a potent synthetic opiate, is more lipophilic than is morphine and displays a shorter duration of action and half-life. Peak analgesia is reached within minutes of IV administration and only lasts for 30-60 minutes.

# Diet

Patients should resume eating and drinking as soon as possible after surgery. Clear liquids can be offered as soon as the patient is awake, alert, and capable of swallowing. In most cases, solid food can be provided on postoperative day 1.

In 2014, the Cochrane Collaborative reviewed “early feeding” after gynecologic surgery, defined as oral intake of fluids or food within the first 24 hours after surgery, regardless of the presence of

signs that indicate the return of bowel function. This review concluded that early feeding is safe and does not lead to negative outcomes, such as postoperative nausea and vomiting, abdominal distension, or need for a postoperative nasogastric tube. Early feeding has been associated with a faster return of GI function, reduced morbidity (less infectious complications and improved wound healing), and improved patient quality of life (satisfaction and ambulation).

# Fluids and Electrolytes

Postoperative fluid replacement should account for intraoperative blood loss and insensible losses as well as maintenance requirements, loss from drains, and third-space losses from tissue edema, ascites, and ileus. IV fluid replacement is particularly important in patients who are not able to tolerate oral fluids. A rough estimate of daily maintenance requirements for sensible and insensible losses can be obtained by multiplying the patient's weight (in kilograms) times 30 mL (eg, 1800 mL/24 h in a 60-kg patient). Fever and hyperventilation can increase maintenance requirements. Sepsis and bowel obstructions will require ongoing fluid replacement beyond maintenance. Clinical signs such as urine output, heart rate, and blood pressure can guide fluid management in patients with normal renal function.

After surgery, the initial recovery period is characterized by fluid retention. Diuretics should be given with caution in the period of fluid sequestration because of possible intravascular volume depletion and symptomatic hypovolemia. Once the stress response subsides, fluid retention subsides, and fluid is mobilized from the periphery. This fluid mobilization is evident by decreased peripheral edema and increased urine output. Fluid supplementation typically becomes unnecessary after this point.

Fluid requirements must be reevaluated frequently after surgery and orders should be revisited every 24 hours or more often if indicated by special circumstances. Following an extensive operation, it may be necessary to reevaluate fluid needs every 4-6 hours during the first 24 hours after surgery.

Traditional surgical management includes provision of dextrose-containing IV fluids, such as 5% dextrose in normal saline or in lactated Ringer solution. The goal of the administration of dextrose-containing IV fluids is not to provide sufficient calories for nutritional support but simply to provide enough carbohydrate to prevent breakdown of lean body mass. If intake is insufficient to meet the requirement of key vital organs, the body metabolizes hepatic glycogen to provide glucose. Once hepatic glycogen stores have been depleted (after about 1 day of no intake), lean muscle mass is converted to glucose via gluconeogenesis. Provision of only 100 g of exogenous glucose per day is sufficient to prevent breakdown of lean muscle mass in otherwise healthy subjects.

The choice of postoperative fluid therapy depends on the patient's comorbidities, the type of surgery, and other conditions that affect the patient's fluid balance (**TABLE 11.2**). Potassium supplementation is not necessary in the immediate postoperative period. Potassium enters the circulation due to operative trauma and increased aldosterone activity leads to reduced excretion.

## TABLE 11.2
## Composition of Intravenous Fluids

| | (mOsm/L) | $Na^+$ (mEq/L) | $Cl^-$ (mEq/L) | $K^+$ (mEq/L) | $Ca^{++}$ (mEq/L) | GLUCOSE (g/L) | pH |
|---|---|---|---|---|---|---|---|
| Normal plasma | 290 | 140 | 103 | 4 | 2.2 | 0.7-1 | 7.4 |
| 0.9% NaCl | 308 | 154 | 154 | | | | 5.5 |
| Lactated Ringer | 270 | 130 | 109 | 5 | 2 | | 6.5 |
| 5% dextrose 0.45% NaCl | 415 | 77 | 77 | 0 | 0 | 50 | 4 |

# *Measurement of Serum Electrolytes*

Routine measurement of serum electrolytes is not necessary for patients requiring IV fluid replacement for a short period. Patients with significant medical comorbidities (such as type I diabetes or chronic kidney disease) and those with extra fluid losses, sepsis, preexisting electrolyte abnormalities, or other complicating factors may warrant electrolyte assessment.

# Foley Management

After pelvic surgery, 20%-50% of patients experience postoperative urinary retention, with the highest rates after surgery for pelvic organ prolapse or urinary incontinence. The causes of postoperative urinary retention are multifactorial, including local inflammation, decreased detrusor contractions, and impaired sensation of bladder fullness. To reduce catheter-associated urinary tract infections and promote ambulation, the use of indwelling Foley catheters should be minimized after gynecologic surgery. In some cases, it may be prudent to assess the patient's voiding function at the time of catheter removal. A voiding trial prior to hospital discharge should be considered for patients at high risk of urinary retention.

## *Passive Voiding Trial*

At the conclusion of surgery, the Foley catheter is removed in the operating room. The patient is given up to 6 hours to spontaneously void. If the patient urinates >200 mL and feels subjectively empty, the patient is considered to have "passed" the voiding trial. However, if the patient is unable to urinate, the bladder is scanned. If the bladder volume is >500 mL, the patient is diagnosed with postoperative urinary retention, the Foley is replaced, and a voiding trial is repeated in 24-48 hours. Patients with urinary retention who otherwise meet criteria for hospital discharge are sent home with a catheter after being provided with instructions for catheter care. If the patient is unable to void but the bladder scan reveals <500 mL of urine, the patient should be given additional time to spontaneously void. Typically in such cases, additional hydration is provided.

## *Active Voiding Trial*

The patient is transferred to the recovery area with the Foley catheter in place. After the initial recovery period, the bladder is backfilled with 300 mL of sterile saline. The Foley catheter is removed and the patient is given up to 30 minutes to urinate. If the patient is able to void >200 mL and feels subjectively empty, the

patient is considered to have “passed” the voiding trial. If the volume is <200 mL or the residual volume is >1/3 of the original instillation, the Foley catheter is replaced, and a voiding trial is repeated in 24-48 hours.

A recently published RCT compared passive and active voiding trials on time to hospital discharge and rates of urinary tract infection and urinary retention. Active voiding trial was associated with a 63% reduction in urinary tract infection, 3.6-hour reduction in time to void, and no differences in urinary retention rates.

# INTERMEDIATE POSTOPERATIVE CARE

## Postoperative Delirium

### *Diagnosis of Delirium*

Delirium is an acute cognitive dysfunction marked by fluctuating disorientation, sensory disturbance, and decreased attention. While delirium is experienced by nearly 10%-25% of all postoperative patients, the impact is highest in the elderly population.

#### Risks for Delirium

Pain and delirium frequently coexist, and each can potentiate the development of the other. The surgical plan should regularly assess the efficacy of pain control and monitor for early signs of delirium. The postoperative phase of surgery exposes patients to many other factors that may precipitate or exacerbate delirium (**TABLE 11.3**). Frail patients are particularly vulnerable to these risk factors and are more susceptible to developing dementia. These factors can augment each other, and the result may be a vicious cycle. For example, postoperative pain can lead to decreased mobility, causing respiratory compromise, atelectasis, and hypoxemia. Escalating doses of narcotics to treat pain can cause respiratory depression and respiratory acidosis. Hypoxemia and delirium can cause agitation, prompting treatment with benzodiazepines, further

worsening respiratory function, and delirium. Serious complications or even death can result if this vicious cycle is not interrupted.

## TABLE 11.3
## Risk Factors for Postoperative Delirium

| INTRINSIC FACTORS | EXTRINSIC FACTORS |
|---|---|
| • Age (>65)<br>• Dementia<br>• Alcohol abuse<br>• History of postoperative delirium<br>• Use of psychiatric medications<br>• Depression<br>• Anemia<br>• Diabetes mellitus | • Blood loss<br>• Surgical duration<br>• Depth of anesthesia<br>• Admission to intensive care unit<br>• Infection<br>• Pain<br>• Sleep disturbance<br>• Use of physical restraints |

Adapted from Schenning KJ, Deiner SG. Postoperative delirium in the geriatric patient. *Anesthesiol Clin*. 2015;33(3):505-516. Copyright © 2015 Elsevier. With permission.

## Evaluation of the Patient With Delirium

Once the diagnosis of postoperative delirium is established, it is important to recognize that some of the causes of delirium are potentially life threatening, and immediate action is necessary. The history should focus on precipitating events such as falls or acute change in medications used (opioids and sedation). The surgeon should always consider alcohol withdrawal, as alcohol use is underreported. Review of vital signs and labs or hypoxemia may suggest sepsis, hypovolemia, anemia, or dehydration. A focused physical examination should concentrate on common sites of infection (lungs, wound, and catheter). Urinary retention may be present because of medication or infection. The most useful labs would include a blood glucose level, complete metabolic panel, and

CBC, looking for anemia. In patients with unstable vital signs, the basic ABCs (“airway” or airway control, “breathing” or supplemental oxygen, and “circulation” or fluid volume expansion) should first be addressed.

## *Treatment of Delirium*

Treatment of postoperative delirium should first address the underlying causes. Once those have been corrected, it is important to remember that delirium resolution may be delayed. In particular, sleep cycles and orientation may be slow to return among critically ill and elderly patients. Family members and friends should be encouraged to provide daytime stimulation and orientation and to promote nighttime rest. Regular mealtimes and orienting communication are simple and effective. A dark room, quiet throughout the evening, and minimization of interruptions help promote sleep. If the patient requires sedation, neuroleptics such as haloperidol, atypical neuroleptics like olanzapine, or low-dose serotonin reuptake inhibitors such as trazodone are better tolerated than are benzodiazepines.

## *Prevention of Delirium*

It is estimated that ~30%-40% of delirium can be prevented. Partridge et al. were able to significantly reduce the incidence of delirium by performing a comprehensive preoperative geriatric assessment, with multidisciplinary interventions as indicated. Examples of strategies to reduce delirium include early mobilization after surgery, sensory stimulation focusing on orientation, cognitive activation, and nutritional assistance. Identifying risk factors for each patient preoperatively (orientation, mobilization, nutritional status, sleep, decreased medication use, and pain/anxiety) allows for perioperative optimization. Intraoperatively, the use of bispectral index-guidance to control the depth of anesthesia has been suggested to reduce the risk of delirium. Given the multifactorial nature of delirium, no single intervention has proved superior to others in the prevention of delirium. Multicomponent, perioperative,

and multidisciplinary interventions should be implemented to prevent patients from developing delirium.

# Cardiac Complications

## *Hypertensive Disease*

Patients with poorly controlled hypertension preoperatively (diastolic blood pressure >110 mm Hg) tend to have more blood pressure lability after surgery as compared to those with well-controlled hypertension. Several possible triggers may raise blood pressures in the first 24 hours after surgery. First, an abrupt withdrawal of β-blocker or of centrally acting sympatholytic agents such as clonidine can cause rebound hypertension. Later in postoperative recovery, sympathetic hyperactivity may stem from inadequate pain management or from alcohol withdrawal. Finally, fluid overload and hypertension can be seen with the return of excess interstitial fluid back into the vascular space. For acute blood pressure management, the mean blood pressure should not be lowered by more than 20% or to a level <160/100 mm Hg.

## *Shock*

Shock is a state of circulatory failure causing either organ hypoperfusion or cellular derangement in oxygen and energy utilization leading to anaerobic metabolism. Shock can be diagnosed by clinical (ie, hypotension, tachypnea, absent distal pulses), laboratory (ie, lactate), or hemodynamic (Swan-Ganz catheter, transthoracic echocardiography) criteria. Most cases of shock are diagnosed and managed using information from all three sources.

Shock is classified into four different categories based upon the underlying pathophysiologic alteration: hypovolemic, distributive, cardiogenic, and obstructive. Common causes of hypovolemic shock include hemorrhage, dehydration, and GI losses (diarrhea, vomiting). The various causes of distributive shock include sepsis, spinal cord injury with neurogenic shock, adrenal insufficiency, anaphylaxis, and ischemia/reperfusion. Cardiogenic shock may be caused by an acute

MI, severe valvular lesions, and myopathies induced by ischemia, viral diseases, and inflammatory conditions. Causes of obstructive shock include tension pneumothorax, cardiac tamponade, constrictive pericarditis, and acute pulmonary embolism (PE).

Treatment of shock should be directed toward the underlying pathology. While shock may be induced by a single etiology, recognizing that multiple etiologies coexist, and that one type of shock may cause or exacerbate a second is crucial to determine the most appropriate therapy.

# *Cardiogenic Shock*

Cardiogenic shock is uncommon after gynecologic surgery. Treatment relies on diagnosis and identification of the reason for pump failure. Physical examination, EKG, cardiovascular labs (troponins, pro-brain natriuretic peptide), and imaging are key in the diagnosis. The most common cause of postsurgical cardiac failure in gynecologic patients is MI.

# *Myocardial Infarction*

Postoperative MI is rare, although incidence may be as high as 37% among patients who undergo surgery within 3 months following an MI. The risk of perioperative coronary ischemia and infarction is exacerbated by declines in oxygen supply and increased demand. Events that decrease oxygen supply include hypotension, lowered coronary perfusion, or poor carrying capacity caused by anemia. Increased myocardial oxygen demands may result from increased afterload, tachycardia, and increased cardiac contractility.

Most patients with postoperative MI do not have classic symptoms of chest pain or pressure. These are in part masked by postoperative analgesics. The most common presenting complaint is dyspnea. ECG changes of postoperative MI do not always demonstrate classic findings, such as S–T changes and pathologic Q waves and tend to be less well defined. CK isoenzyme (CK-MB) abnormalities are seen within 6 hours, and cardiac troponins I and T are highly specific later for diagnosis of MI.

Postoperative MI treatment differs from that of nonsurgical patients, and its main tenets focus on shifting the oxygen delivery and utilization balance. Cardiology and/or critical care consultation should be requested for patients with postoperative MI. Special attention is given to arrhythmia correction and hemodynamic status improvement. A cardiac critical care unit is best for providing continuous monitoring, cardiopulmonary support, and cardiology consultation.

# Pulmonary Complications

Postoperative pulmonary complications after gynecologic surgery remain an important cause of increased morbidity, mortality, and resource use. Atelectasis, pneumonia, and pulmonary thromboembolic disease continue to occur following abdominal surgery despite continuing advances in anesthetic, surgical, and postoperative treatment. This may be because gynecologic surgery is increasingly performed in patients with advanced age and multiple comorbid conditions, who are at increased risk for the development of postoperative pulmonary complications. Risk factors for postoperative pulmonary complications in patients undergoing a gynecologic surgery procedure vary among studies but are consistent with other patient groups undergoing abdominal surgical procedures.

## *Effects of Anesthesia*

General anesthesia results in important alterations in respiratory physiology (**TABLE 11.4**). Anesthetic agents influence not only the ventilatory response to oxygen and carbon dioxide but also the pattern of respiration. Inhalational agents and IV agents both result in a reduction of the ventilatory response but differ in their effects on respiratory pattern. The classic breathing pattern produced by inhalational anesthetics is a rhythmic, rapid, and shallow pattern of respiration with no intermittent sighs (large breaths), whereas IV anesthesia is associated with slow, deep respirations.

## TABLE 11.4
## Effects of Anesthesia on Respiratory Physiology

| |
|---|
| Reduced ventilatory response to oxygen and carbon dioxide |
| Rhythmic rapid shallow breathing pattern |
| Reduced functional residual capacity |
| Diaphragmatic dysfunction |
| Atelectasis |
| Ventilation-perfusion mismatching |
| Blunting of hypoxic pulmonary vasoconstriction |
| Impairment in mucociliary clearance |

During surgery, there is only modest metabolism of inhalational anesthetics, with most of the anesthetic agents stored in the tissues, such as muscle and fat. At the conclusion of anesthesia, most of the stored anesthetic agent is eliminated via the lungs. Long anesthetic times can lead to significant concentrations of the anesthetic agent, leading to tissue storage well into the recovery phase. This prolonged anesthetic effect can lead to clinically significant respiratory depression in the postoperative period.

The changes in pulmonary function observed following anesthesia and surgery are principally the result of decreased vital capacity, functional residual capacity, and pulmonary edema. These changes are accentuated in patients who are obese, who smoke heavily, or who have preexisting lung disease. The number of functional alveolar units participating actively in gas exchange is directly related to functional residual capacity. Elderly patients are particularly vulnerable because they have decreased lung compliance, increased closing volume, increased residual volume, and increased dead space, all of which enhance the risk of postoperative atelectasis.

The postoperative decrease in functional residual capacity is caused by shallow tidal breaths without periodic maximal inflation thought in part to be caused by pain. In normal human respiration, total lung capacity insufflation occurs several times each hour. If these maximal inflations are eliminated, alveolar collapse begins to occur within a few hours leading to transpulmonary shunting and atelectasis. An important change following surgery is a shift in respiratory pump function from the diaphragm to accessory inspiratory and expiratory muscles of respiration. This results in a rapid shallow breathing pattern of respiration. The contractile function of the diaphragm is impaired by inhibition of phrenic nerve output by stimulation of visceral and somatic nerve pathways during manipulation of the abdominal viscera and the peritoneum. Reduction in functional residual capacity can have marked adverse effects on perioperative gas exchange, especially the development of hypoxemia.

# *Atelectasis*

Atelectasis is conceptually the absence of gas from a part or the whole of the lungs that is due to the failure of expansion or resorption of gas from the alveoli. Unfortunately, the definition of atelectasis is not uniform across clinical studies as most studies bundled atelectasis into a global definition of postoperative pulmonary complications. The generally accepted criteria for the diagnosis of atelectasis include impaired oxygenation in a clinical setting where atelectasis is likely, unexplained temperature of >38 °C, and chest radiographic evidence of volume loss or new airspace opacities.

The pathophysiologic effects of atelectasis include decreased respiratory compliance, increased pulmonary vascular resistance, predisposition to acute lung injury, and hypoxemia. It occurs in the dependent areas of the lungs within 5 minutes of anesthetic induction in a patient with healthy lungs and leads to shunt physiology. Although most gynecologic surgery is done in the pelvis, extension of the surgical incision and operative procedure into the upper abdomen increase the respiratory effects (**TABLE 11.5**).

Atelectasis may also be a precursor to more serious postoperative pulmonary complications, such as postoperative pneumonia.

## TABLE 11.5
## Effects of Upper Abdominal Surgery on Respiratory Physiology

| |
|---|
| Reduction in lung volumes: residual volume, total lung capacity, functional residual capacity, and vital capacity |
| Reflex inhibition of phrenic nerve activity resulting in decreased diaphragmatic function |
| Increased neck and intercostal inspiratory accessory muscle use |
| Tonic and phasic contraction of abdominal expiratory muscles |

Risk factors for atelectasis after abdominal surgery include advanced age, obesity, intraperitoneal sepsis, prolonged anesthesia time, nasogastric tube placement, and smoking.

The principal means of minimizing atelectasis is deep breathing. Early mobilization and encouragement to take deep breaths (especially when standing) are sufficient for most patients. Periodic hyperinflation can be facilitated by using an incentive spirometer. This is particularly useful in patients with a higher risk of pulmonary complications (eg, elderly, debilitated, or markedly obese patients). Voluntary lung inflation exercises enable redistribution of gas into areas of low compliance. Effective deep breathing exercises require the patient to be conscious and cooperative. Routine chest physiotherapy is not recommended after abdominal surgery because it may exhaust the patient and can induce bronchospasm, which would lead to transient hypoxemia.

The risk of atelectasis may be reduced by several interventions. Less atelectasis is seen after laparoscopic procedures as compared to open surgery through decreased postoperative pain and, therefore, less adverse effects on postoperative respiratory muscle

function. Also, preoperative smoking cessation is effective if it is started well in advance of surgery (6-8 weeks before operation). However, if smoking cessation is attempted closer to the time of a planned surgical procedure, the improvement in mucociliary clearance in combination with reduced cough may lead to a secretion burden that paradoxically increases the risk of postoperative pulmonary complications.

# *Pulmonary Edema*

Postoperative pulmonary edema is caused by high hydrostatic pressures (due to left ventricular failure or fluid overload, increased capillary permeability, or both). Edema of the lung parenchyma narrows small bronchi and increases resistance in the pulmonary vasculature. In addition, pulmonary edema may increase the risk of pulmonary infection. Systemic sepsis significantly increases capillary permeability. In the absence of an obvious source, the development of pulmonary edema postoperatively should be regarded as evidence of sepsis. Adequate management of fluids postoperatively and early treatment of cardiac failure are important preventive measures.

# *Pneumonia*

Hospital-acquired pneumonia (HAP) is the second most common nosocomial infection in the United States, with high rates of associated morbidity and mortality. Its incidence in surgical patients varies and ranges from 1% to 19%, depending on surgical procedure and hospital surveyed. The most common bacterial pathogens causing HAP include aerobic Gram-negative bacilli, such as *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Acinetobacter* species.

The nonspecific clinical findings make the diagnosis of HAP difficult. The 2016 Infectious Diseases Society of America/American Thoracic Society guidelines for the management of HAP continue to recommend a clinical diagnosis based upon a finding of a new lung infiltrate plus clinical evidence that the infiltrate is of infectious origin,

which includes the new onset of fever >38 °C, purulent sputum, leukocytosis, and decline in oxygenation. HAP develops 48 hours or more after hospital admission and is caused by an organism that was not incubating at the time of hospitalization.

Broad-spectrum antibiotic regimens are recommended for HAP treatment (**TABLE 11.6**). If aspiration is highly suspected, specific treatment for anaerobes (with metronidazole or clindamycin) is considered. An algorithm supported by the American Thoracic Society is shown in **FIGURE 11.1**.

## TABLE 11.6
## Management of Hospital-Acquired Pneumonia (HAP) Outside the Intensive Care Unit

| | |
|---|---|
| Beta-lactam/beta-lactamase inhibitor<br>Or<br>Third-generation nonpseudomonal cephalosporin:<br>Or<br>Fluoroquinolones | **Early-onset HAP**<br><5 d |
| Antipseudomonal cephalosporin<br>Or<br>Fluoroquinolones | **Late-onset HAP**<br>>5 d |
| Beta-lactams<br>+<br>Aminoglycoside<br>Or<br>Quinolone | **Severe HAP with risk factors for**<br>*P aeruginosa*<br>Gram-negative bacilli |
| Carbapenems<br>Or<br>Beta-lactam/beta-lactamase inhibitor | **Anaerobes** |
| Vancomycin<br>Or<br>Linezolid | **MRSA** (methicillin-resistant *S aureus*) |

Adapted from Kalil AC, Metersky ML, Klompas M, et al. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the Infectious Diseases Society of America and the American Thoracic Society. *Clin Infect Dis*. 2016;63(5):e61-e111; Di Pasquale M, Aliberti S, Mantero M, et al. Non-intensive care unit acquired pneumonia: a new clinical entity? *Int J Mol Sci*. 2016;17(3):287. https://creativecommons.org/licenses/by/4.0/.

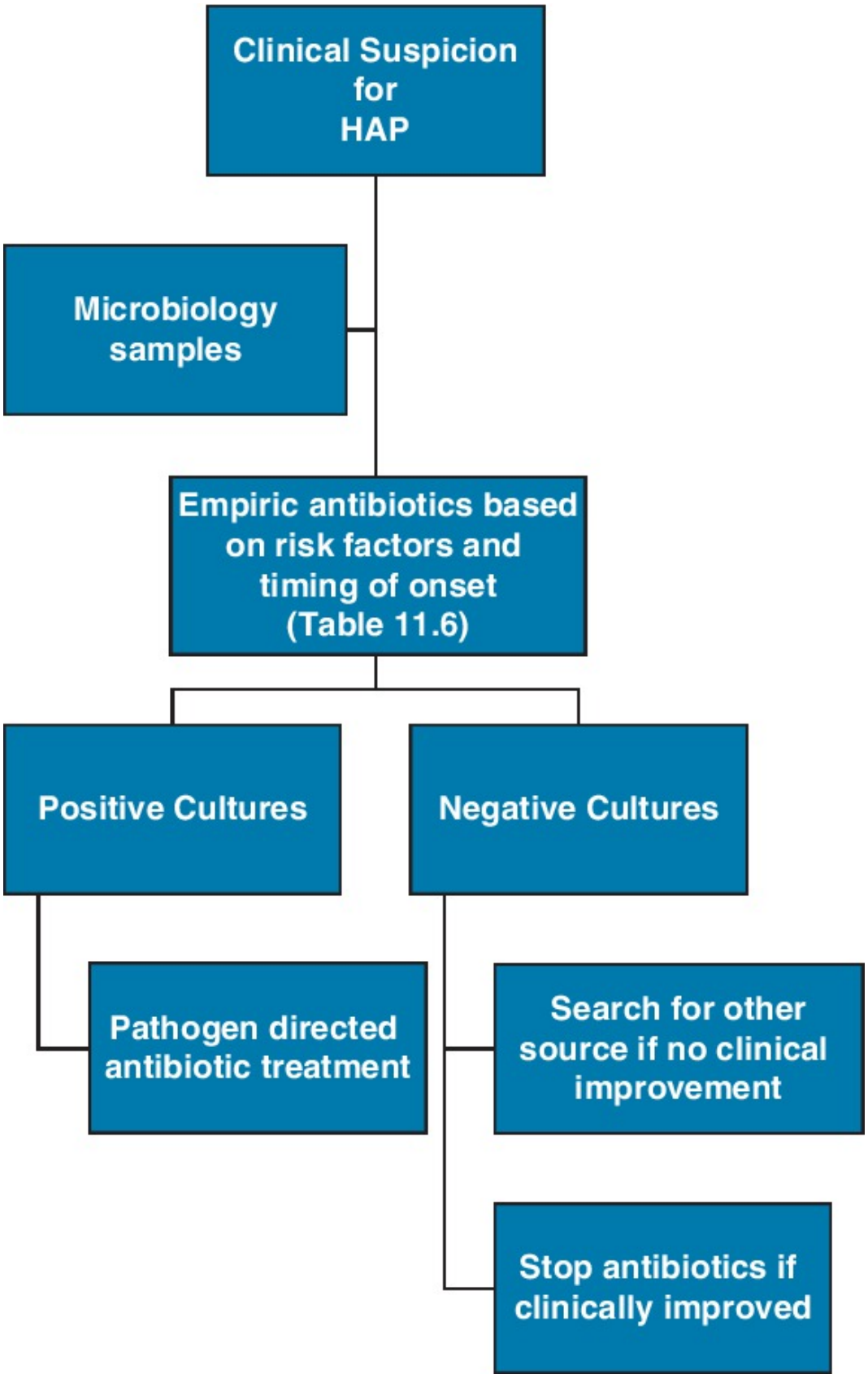
Clinical Suspicion for HAP
Microbiology samples
Empiric antibiotics based on risk factors and timing of onset (Table 11.6)
Positive Cultures
Negative Cultures
Pathogen directed antibiotic treatment
Search for other source if no clinical improvement
Stop antibiotics if clinically improved

**FIGURE 11.1** Algorithm for the treatment of hospital-acquired pneumonia. (Adapted from Di Pasquale M, Aliberti S, Mantero M, et al. Non-intensive care unit acquired pneumonia: a new clinical entity? *Int J Mol Sci*. 2016;17(3):287. doi:10.3390/ijms17030287. https://creativecommons.org/licenses/by/4.0/)

Initial therapy should be administered intravenously, with a switch to the enteral route of administration in selected patients who have a good clinical response and a functional GI tract. Combination therapy should be used initially if patients are at high risk of being infected with a multidrug-resistant pathogen. Monotherapy is appropriate for those patients deemed to be low risk. Duration of therapy, typically 8 days, should be based on clinical response. If the etiologic pathogen is *P aeruginosa*, a longer course (15 days) is required. Clinical improvement usually takes 48-72 hours, and therapy should not be changed during this time unless there is a rapid clinical decline. The responding patient should have therapy tailored to culture results. The nonresponding patient should be evaluated for drug-resistant organisms, complications of pneumonia (eg, parapneumonic effusion or empyema), extrapulmonary sites of infection, or noninfectious causes of symptoms and signs of pneumonia (eg, drug fever with drug-induced lung injury).

## *Respiratory Failure*

Respiratory failure presents with tachypnea (eg, 25-30 breaths/min) with a low tidal volume. Laboratory indications are acute elevation of $PCO_2$ above 45 mm Hg and depression of $PO_2$ below 60 mm Hg. Risk factors for early respiratory failure are major upper abdominal operations, severe trauma, and preexisting lung disease. Most patients tolerate the postoperative changes in pulmonary function without difficulty. Patients who have marginal preoperative

pulmonary function may be unable to maintain adequate ventilation in the immediate postoperative period and may develop respiratory failure.

In most patients afflicted by this condition, respiratory failure develops over a short period (up to 2 hours) without evidence of a precipitating cause. In contrast, late postoperative respiratory failure (which develops beyond 48 hours after the operation) is usually triggered by an intercurrent event such as PE, abdominal distension, or opioid overdose.

Initial treatment consists of immediate endotracheal intubation and ventilatory support to ensure adequate alveolar ventilation. After intubation, it is important to determine whether there are any other associated pulmonary problems that require immediate treatment, such as atelectasis, new-onset pneumonia, or a pneumothorax.

Prevention of respiratory failure requires careful postoperative pulmonary care. First, it is important to avoid dehydration in patients with preexisting pulmonary disease. This is because compensation for the inefficiency of the lungs occurs through hyperventilation and this extra work causes greater evaporation of water and dehydration. Hypovolemia leads to dry secretions and thick sputum, which are difficult to clear from the airway. Second, alveolar collapse can occur with displacement of the stabilizing gas nitrogen from the alveoli by high fraction of inspired $O_2$ ($fiO_2$). Finally, high $fiO_2$ may also impair the function of the respiratory center, which is driven by the relative hypoxemia, and thus further decrease ventilation.

# Gastrointestinal Complications

Following laparotomy, GI peristalsis temporarily decreases. Peristalsis returns in the small intestine within 24 hours, but gastric peristalsis may return more slowly. Function returns in the right colon by 48 hours and in the left colon by 72 hours.

## *Postoperative Nausea and Vomiting*

Postoperative nausea and vomiting is one of the most common complaints following surgery, with incidence ranging from 30% to

70% in high-risk patients. Those at increased risk for postoperative nausea and vomiting include females, nonsmokers, those with prior motion sickness or prior postoperative nausea and vomiting, and those with extended surgeries.

Pharmacologic prevention of postoperative nausea and vomiting should be tailored to the patient's risk levels. The recovery process is facilitated by using a combination of prophylactic antiemetic agents in patients with moderate/high risk of developing postoperative nausea and vomiting. Key elements to enhance recovery after surgery also include opioid-sparing analgesic techniques and proper hydration. Persistent nausea may benefit from combining agents from different classes (**TABLE 11.7**).

## TABLE 11.7
## Antiemetic Medications

| NAME | CLASS | DOSAGE[a] | COMMENTS |
|---|---|---|---|
| Diphenhydramine | Antihistamine | 25-50 mg PO q6h<br>25 mg IV/IM q6 | • Can cause sedation, constipation, and urinary retention |
| Hydroxyzine | Antihistamine | 25-100 mg PO/IM q6h | • Not for IV use<br>• Can cause sedation, constipation, and urinary retention |
| Phenergan | Phenothiazine derivative | 12.5-25 mg PO/IV/IM q6h | • Has anticholinergic activity<br>• Can cause neuroleptic malignant syndrome, extrapyramidal symptoms, and seizures |
| Prochlorperazine | Phenothiazine derivative | 25 mg suppository q12h | • Has anticholinergic activity<br>• Can cause neuroleptic malignant syndrome, extrapyramidal symptoms, and seizures |
| Metoclopramide | Dopamine antagonist | 5-10 mg PO q6h<br>10-20 mg IM q6h | • Useful for migraines and gastroparesis<br>• Can cause neuroleptic malignant syndrome, extrapyramidal symptoms, and seizures |
| Ondansetron | Serotonin antagonist | 4-8 mg PO/IM/IV q6-12h | • Minimal side effects |

[a]Intramuscular (IM); intravenous (IV); oral (PO).

# *Ileus*

Postoperative ileus is a transient impairment of normal GI motility after major abdominal surgery characterized by nausea, vomiting,

bloating, abdominal pain/distension, absence of stool or flatus passage, and accumulation of gas and fluid in the bowel—all with poor tolerance of oral intake. A prolonged ileus is a common complication following laparotomy seen in up to 40% of patients, even if the intestines are not manipulated.

The exact mechanism of a postoperative ileus is not fully understood. Studies suggest that there may be neurologic and inflammatory mechanisms involved. The intestinal walls house inhibitory reflexes within the neural plexus between the GI tract and spinal cord. These neural pathways may account for the development of ileus during laparotomy without bowel manipulation. In addition, inflammatory mediators such as nitric oxide are present in manipulated bowel and in peritonitis and may play a role in the development of ileus. Nonsurgical causes of ileus include medications and electrolyte abnormalities.

Early ambulation has long been held to be useful in prevention of postoperative ileus. While standing and walking in the early postoperative period have been proven to have major benefits in pulmonary function and prevention of pneumonia, mobilization has no demonstrable effect on postoperative ileus.

The impact of chewing gum on shortening the duration of postoperative ileus remains unclear. According to the colorectal literature, gum chewing may reduce time to first flatus and the time to first bowel movement without a significant difference in hospital length of stay. In 2008, the FDA approved alvimopan, a peripheral mu-opioid antagonist that binds to opioid receptors in the GI tract, to prevent postoperative ileus when started preoperatively in selected patients. The role of alvimopan in the care of the postoperative gynecologic patient is uncertain. Minimally invasive surgical approaches and the use of opioid-sparing analgesic protocols are well-established strategies for reducing the incidence of ileus. Narcotic analgesia, while effective for postoperative pain, has been shown to lengthen the duration of postoperative ileus, especially when used as a continuous infusion or as patient-controlled analgesia. Among various opioid medications, there has been no clearly superior drug identified; all currently available opioids cause ileus.

Ileus can be diagnosed in the setting of abdominal distension, nausea, and the absence of bowel sounds and flatus. Abdominal x-ray typically shows dilated loops of small bowel and colon. While there is no specific lab test for the assessment of mechanical ileus, it may be useful to check serum electrolytes to insure normal potassium levels.

Treatment of the patient with ileus is supportive, starting with IV fluids to replace volume deficits and with correction of electrolyte/acid-base disturbances. Selective GI decompression (via nasogastric tube) can be considered in patients with vomiting. If there is any evidence of infection/sepsis, antibiotics should be given early. Conservative treatment can be continued for several days with close clinical and electrolyte observations.

## *Small Bowel Obstruction*

Early postoperative bowel obstruction is defined as a mechanical bowel obstruction, primarily involving the small bowel, which occurs in the first 30 days following abdominal surgery. The clinical presentation of early postoperative bowel obstruction includes crampy abdominal pain, vomiting, abdominal distension, and obstipation. The clinical picture may frequently be mistaken for ileus, and these conditions can overlap (**TABLE 11.8**). Computed tomography (CT) or other contrast imaging may be required to distinguish ileus from obstruction. The incidence of early postoperative bowel obstruction has been variable in published series, due to difficulty in differentiating ileus from early postoperative bowel obstruction; the reported incidence is from 0.7% to 9.5% of abdominal operations.

### TABLE 11.8
### Differential Diagnosis Between Postoperative Ileus and Postoperative Obstruction

| CLINICAL FEATURE | POSTOPERATIVE ILEUS | POSTOPERATIVE OBSTRUCTION |
|---|---|---|
| Abdominal pain | Discomfort from distension but not cramping pains | Cramping progressively severe |
| Relation to previous surgery | Usually within 48-72 h of surgery | Usually delayed, may be 5-7 d for remote onset |
| Nausea and vomiting | Present | Present |
| Distension | Present | Present |
| Bowel sounds | Absent or hypoactive | Borborygmi with peristaltic rushes and high-pitched tinkles |
| Fever | Only if related to associated peritonitis | Rarely present unless the bowel becomes gangrenous |
| Abdominal radiographs | Distended loops of small and large bowels; gas usually present in the colon | Single or multiple loops of distended bowel (usually small bowel) with air-fluid levels |
| Treatment | Conservative with nasogastric suction, enemas, and cholinergic stimulation | Conservative management with nasogastric decompression<br>Surgical exploration |

Retrospective large series show that about 90% of early postoperative bowel obstruction is caused by inflammatory adhesions. These result from injury to the surfaces of the bowel and peritoneum during surgical manipulation. Release of inflammatory mediators after injury leads to the formation of fibrinous adhesions between the serosal and peritoneal surfaces. As the inflammatory mediators are cleared and the injury subsides, these adhesions eventually mature into fibrous, firm, and bandlike structures.

Internal hernia is the next most common cause of early postoperative bowel obstruction and can be difficult to diagnose short of surgical exploration. Internal hernia occurs when gaps or defects are left in the mesentery or omentum or when blind gutters or sacs are created during abdominal surgery. Herniation can also occur through defects in the abdominal wall, especially related to failure to achieve adequate closure of the fascia during open or laparoscopic surgery. Unlike adhesive obstruction, internal hernia requires operative intervention due to the high potential for complete obstruction and strangulation of the bowel. Fortunately, internal hernia is a rare occurrence in the early postoperative period; however, it must be suspected in cases where bowel anastomoses or colostomies have been constructed.

Management of early postoperative bowel obstruction depends on differentiation from ileus and on identifying the cause (eg, adhesive bowel obstruction [the majority] versus internal hernia or other causes). Clinicians generally rely on radiographic imaging to discern ileus from obstruction. Upright plain abdominal films demonstrate air/fluid levels and distension in both conditions and the differentiation between ileus and obstruction can, therefore, be confusing. An abdominal CT with and without IV contrast will allow for localization and determination of grade, severity, and etiology of a suspected postoperative bowel obstruction. The sensitivity and specificity of CT for high-grade bowel obstruction and identifying intestinal ischemia is >90%. The American College of Radiology recommends that oral contrast not be used if high-grade small bowel obstruction is known or suspected because it does not add to diagnostic accuracy and can lead to vomiting and aspiration.

Once the diagnosis is made, management is tailored to the specific needs of the patient. Decompression via nasogastric tube is usually indicated. Rest, decompression, and maintaining euvolemia are key. A radiographic fluoroscopic small bowel follow through (also known as the water-soluble contrast challenge) should be attempted as part of the nonoperative management plan. The two most common water-soluble contrast agents are Gastrografin (Bracco Diagnostics Inc., Monroe Township, NY) and Gastroview (Mallinckrodt Inc., St. Louis, MO). Both of these agents are considered potentially therapeutic, in that they have been shown to decrease time to resolution and hospital duration of stay. The contrast is ingested via nasogastric tube after 2-6 hours of decompression. The nasogastric tube should remain clamped and serial radiographs are repeated every 8-12 hours until contrast reaches the colon, at which time a trial with clear liquids can be attempted.

Adhesive bowel obstruction warrants a period of expectant management and supportive care, as most of these problems will resolve spontaneously with supportive care and expectant management. No data exist to guide how long the surgeon should conservatively treat a small bowel obstruction. In appropriately selected patients, 2-5 days is reasonable. After 14 days of

conservative management, <10% will resolve spontaneously, and therefore, surgical exploration should be considered. Expedited surgical correction should be recommended in the setting of complete obstipation or when abdominal CT suggests internal hernia, complete bowel obstruction, or strangulation.

# *Diarrhea*

When diarrhea presents while patients are on antibiotics (or for up to 8 weeks after discontinuation of antibiotics), the condition is defined as antibiotic-associated diarrhea. Nearly one-third of cases of antibiotic-associated diarrhea in adults are due to *Clostridiodes difficile*. *C difficile* infections are the most common health care–associated diarrhea, and antibiotic stewardship is critical to protecting the intestinal microbiota.

Three of the most important risk factors for *C difficile* infection are older age, use of antibiotics, and hospitalization. While *C difficile* infection can involve any part of the colon, the distal segment is the most common site of infiltration. *C difficile* infections should be considered if a patient presents with acute diarrhea defined as >3 loose, watery stools that “take the shape of the container” over the course of 24 hours. Other signs and symptoms may include fever, nausea, vomiting, abdominal pain, and tenesmus. The diagnosis is aided by testing for the *C difficile* organism, the toxin, or toxin-producing gene. Testing should not occur if patients have received laxatives in the prior 48 hours.

Once a *C difficile* infection has been confirmed, discontinuation of the offending antibiotic therapy should be considered. Most patients who have mild diarrhea will recover spontaneously within 5-10 days of antibiotic therapy withdrawal. The antibiotics that present the highest risk for *C difficile* include clindamycin, broad-spectrum penicillins, and more recently fluoroquinolones. In moderate to severe cases, recent studies suggest that oral vancomycin (125 mg QID for 10 days) is more effective with less recurrence rates than metronidazole. Fidaxomicin is an oral macrocyclic antibiotic that is bactericidal against *C difficile* and is another option for refractory *C difficile* infections.

For most cases, oral fluid therapy with a small amount of food is sufficient to maintain hydration. Replacing electrolytes should be considered if the patient is elderly or shows signs of severe dehydration due to frequent vomiting.

## *Total Parenteral Nutrition*

A short period of deficient nutritional intake is expected after an abdominal/pelvic procedure and is typically well tolerated. However, in already malnourished patients, or in patients with delayed return of postoperative bowel function (beyond 7 days), nutritional support should be initiated.

While some postoperative gynecologic patients may require parenteral support, the enteral route is preferred, as it has been shown to cause less morbidity. Enteral nutritional support is effective in patients that have functional small bowel. If the patient cannot swallow, nasogastric tubes can be used effectively to deliver full support. Patients that need long-term enteral support are best served with gastrostomy or jejunostomy tubes.

Some hospitalized patients may require total parenteral nutrition (TPN) for disease processes such as GI tract obstruction, prolonged ileus, short bowel syndrome, radiation enteritis, intra-abdominal abscess, pancreatitis, regional enteritis, and enterocutaneous fistula. A patient with any condition that prevents oral intake of adequate nutrition for more than 7-10 days probably requires central parenteral nutrition. Because it is much easier to maintain an adequate nutritional state than to improve a poor one, the decision to use TPN should not be delayed. Parenteral nutrition may be administered through peripheral or central venous access, depending on the patient's initial nutritional status and the time required on TPN.

Irrespective of the route of support, every patient on nutritional support should have his or her nutritional needs assessed on a regular basis to ensure adequate nutrition is provided. The assessment begins with the calorie and protein requirement, estimated using formulas and nomograms to estimate basal energy expenditure and take into account height, weight, age, gender, stress factors, and activity factors. The baseline caloric requirement for

weight maintenance based on adjusted body weight is 25 kcal/kg/d, and protein is ~1-1.5 g/kg/d in postoperative patients. This target may be adjusted upward in patients with extreme metabolic demands. Be aware that the estimations may underfeed or overfeed certain subgroups, especially the obese.

Essential nutritional components must be provided, again irrespective of the route of support. These include carbohydrates, fat, protein, water- and lipid-soluble vitamins, electrolytes, trace elements, and essential fatty and amino acids. Trace elements are provided in abundance in all enteral feeds and are part of the standard additives in parenteral formula.

In some hospital settings, the administration of TPN is facilitated by a specialized team of physicians, nurses, and health care professionals. Although the composition and exact function of the team members vary between hospitals, most teams consist of a physician, nurse, pharmacist, and nutritionist. The role of the team varies in each institution from consultation to complete management of the patient's nutritional needs. The team approach by either method is highly beneficial because it provides a high concentration of personnel with knowledge, expertise, and interdisciplinary communication at the patient's bedside. Team members can provide continuing education on nutrition therapy, continuously audit, and collect quality control data and investigate ways to improve the safety and efficacy of TPN as a treatment modality. Most teams operate with a standardized protocol that covers patient assessment, catheter insertion techniques, solutions used, and monitoring functions performed.

Once the patient can tolerate an enteral diet that provides adequate calories, the surgeon can discontinue TPN. However, an abrupt discontinuation of central parenteral nutrition may result in rebound hypoglycemia. Our recommendation is to decrease the total hyperalimentation solution stepwise to 42 mL/h before discontinuation. Some institutions recommend that the patient receive 10% dextrose for an additional 12 hours once central parenteral nutrition has been discontinued.

# Renal Complications and Electrolyte Imbalances

Postoperative management of the GU system includes close monitoring of urine output and electrolytes, avoidance or judicious use of nephrotoxic medications, daily weight, and adjustment of all medications that are cleared by the kidney. Perioperative mortality increases in the face of postoperative renal failure. Preoperative dehydration can result in hypovolemia or intraoperative hypotension, both of which increase the risk of postoperative renal failure. Nephrotoxic drugs and contrast nephropathy are common causes of hospital-acquired renal failure.

Rising blood urea nitrogen and creatinine along with postoperative oliguria (<0.5 mL/kg/h) signify the onset of postoperative renal failure. A systematic approach can help differentiate the cause of acute renal failure into three categories: prerenal, intrarenal, and postrenal insults.

## *Oliguria*

Prerenal oliguria is a physiologic response to hypovolemia and is common in the postoperative period. Decreased renal perfusion can be caused by hypovolemia due to acute hemorrhage, vomiting, severe diarrhea, and inadequate intraoperative volume replacement. In addition to oliguria, volume depletion results in tachycardia and orthostatic hypotension. In response to hypovolemia, the renin-angiotensin system is activated, and antidiuretic hormone is released to prompt reabsorption of sodium and water by the renal tubules. Volume replacement is the key principle of treatment of prerenal oliguria. Thus, an accurate assessment of the patient's fluid deficit is critical.

Decreased renal perfusion due to a prerenal state may contribute to acute renal failure. Necrosis of the renal tubules can be caused by an ischemic injury. Additionally, in a prerenal setting, the renal tubules are more vulnerable to insult from nephrotoxic agents such as NSAIDs, aminoglycosides, and contrast media.

Calculating the fractional excretion of sodium ($FE_{Na}$) using the sodium ($Na^+$) and creatinine (Cr) levels from both serum and urine can help differentiate between intrarenal and prerenal oliguria (**TABLE 11.9**). A ratio <1 suggests a prerenal source, whereas a ratio >3 indicates a postrenal insult. Differences in urine sodium levels are also observed. A level of <20 mEq/L suggests prerenal oliguria, whereas a value >40 mEq/L indicates an intrarenal state.

## TABLE 11.9
## Fractional Excretion of Sodium ($FE_{Na}$)

| | $URINE_{NA}$ | $FE_{NA}$ |
|---|---|---|
| Prerenal | <20 mEq/L | <1% |
| Intrarenal | >40 mEq/L | >1% |
| Postrenal | >40 mEq/L | >3% |

Postrenal oliguria may signify Foley catheter occlusion. In those without a catheter, urinary retention is most likely. More serious causes include ligation or laceration to the ureter or bladder. Hematuria, flank pain, or ileus should prompt consideration of a urinary tract injury. Hydronephrosis on renal sonography is highly sensitive and specific for confirming ureteral obstruction. Other imaging modalities to identify ureteral obstruction include CT with IV contrast or retrograde pyelography. However, IV contrast can be nephrotoxic and may be a less than ideal choice for those with elevated creatinine levels.

# *Electrolyte Imbalance*

Electrolyte abnormalities are common in the postoperative period. Hyponatremia is defined as a serum sodium level <135 mEq/L and may first become symptomatic as levels drop below 125 mEq/L. Aggressive IV crystalloid resuscitation with hypotonic solutions is the

most common cause. Syndrome of inappropriate ADH (SIADH) due to pain or medications can also lead to hyponatremia through water retention. Finally, sodium losses may follow profuse diarrhea, vomiting, or nasogastric suctioning. Severe hyponatremia can lead to metabolic encephalopathy with associated cerebral edema, seizures, increased intracranial pressure, and even respiratory arrest. Unfortunately, symptoms are not correlated with specific serum sodium levels.

The administration of isotonic fluids and treatment of underlying conditions will correct most cases. The speed of correction should ideally not exceed 0.5 mEq/L/h, with a corrected sodium goal of 130 mEq/L. Overaggressive correction can result in osmotic demyelination syndrome.

Conversely, hypernatremia is defined as a serum sodium concentration exceeding 145 mEq/L. Common causes are loss of hypotonic body fluids such as diarrhea, gastric secretions, and sweat. Diabetes insipidus is a condition of renal water wasting, in which an excessive amount of dilute urine is produced. Hypernatremia leads to cell dehydration in an effort to maintain intravascular fluid compartment volume. When not recognized and treated, brain cell shrinkage can result, causing vascular bleeds and permanent neurologic damage. Volume replacement to correct hemodynamic instability is initiated with isotonic fluids or colloid fluids. Brain cell shrinkage is intrinsically corrected through the formation of compensatory compounds called idiogenic osmoles. Therefore, aggressive treatment should be avoided as this can overcorrect to create cerebral edema, seizure, coma, and even death.

Hypokalemia is defined as serum potassium below 3.5 mEq/L. Hypokalemia is usually caused by diarrhea or by abnormal renal loss secondary to metabolic alkalosis. Mild hypokalemia is often asymptomatic, but nonspecific symptoms seen with progression include generalized weakness and constipation. Muscle necrosis can begin when the serum levels fall below 2.5 mEq/L and an ascending paralysis can develop with levels below 2.0 mEq/L. Potassium replacement can be oral or IV. When compared to IV, oral potassium is safer, as it enters the circulation more slowly and reduces the risk

of iatrogenic hyperkalemia. The maximum rate of IV potassium replacement is 20 mEq/h. It should be remembered that magnesium depletion can cause hypokalemia refractory to replacement efforts.

Hyperkalemia (serum potassium concentration >5.5 mEq/L) is most commonly associated with renal disease. It may also be seen in myonecrosis, hemolysis, and acidosis. Pseudohyperkalemia can result from traumatic hemolysis or cellular release from a clotted specimen tube. Unsuspected findings in an asymptomatic patient should prompt repeat measurement. Cardiac arrhythmias are seen at levels above 6.5 mEq/L, and death is associated with levels >8 mEq/L. These patients should have cardiac monitoring until their levels normalize. Treatment of hyperkalemia should attempt to shift potassium back into the cells using IV insulin, nebulized albuterol, or sodium bicarbonate (if the patient is acidotic). IV calcium gluconate will protect the cardiac myocytes and antagonize the effect of potassium on the myocardial conduction system. Cation exchange resins can be administered orally or per rectum to bind ions in the GI tract and facilitate excretion. Dialysis can by employed if other measures fail.

# Postoperative Transfusion

Each year, over 4 million people receive blood transfusions. Different blood or blood components are available to address each indication for transfusion.

Prior to transfusion, pretreatment with acetaminophen and diphenhydramine may be considered to reduce febrile (nonhemolytic) transfusion reactions. Without premedication, however, the incidence of such reactions is <1%. Hemolytic transfusion reactions, which also occur in <1%, are typically due to immunologic incapability between the patient and the unit of blood transfused. Symptoms of a hemolytic transfusion reaction may include flank pain, hematuria, fevers, chills, or shortness of breath. Hemolytic reactions may lead to disseminated intravascular coagulation and renal failure. While hemolytic reactions typically occur during or immediately after transfusion, delayed reactions can occur several days later. Treatment includes immediately stopping

the transfusion, assessing for the severity of hemolysis, and hemodynamic support with IV normal saline.

# *Red Blood Cells*

Red blood cell (RBC) transfusions are indicated to increase oxygen-carrying capacity in anemic patients. Most asymptomatic patients can tolerate hemoglobin levels of 7-9 g/dL. While most use a transfusion trigger of 7 g/dL, patients with cardiac, pulmonary, or cerebrovascular disease may require transfusions at higher hemoglobin levels. One can anticipate an increase in hemoglobin level by 1 g/dL or the hematocrit by 3% for each transfused unit of RBCs.

Packed RBCs are obtained by centrifuging whole blood to remove the plasma and adding 100 mL of red cell nutrient solution. This yields a 300- to 350-mL solution with a hematocrit of 55%-60%. Washed RBCs, on the other hand, are obtained by using saline to remove more than 98% of the plasma proteins from the whole blood precipitate and resuspending it in ~180 mL of saline. Patients with recurrent or severe allergic reactions benefit from washed RBCs. Leukocyte reduction filters can remove more than 99.9% of the contaminating leukocytes. Prestorage leukoreduction is more effective than is bedside filtration. These should be given to patients experiencing recurrent febrile nonhemolytic transfusion reactions to RBCs or platelets. Leukoreduction also decreases the risk of transmission of cytomegalovirus infection in immunosuppressed cytomegalovirus seronegative patients.

# *Platelets*

Platelet transfusions are indicated for the management of active bleeding in thrombocytopenic patients or nonthrombocytopenic patients with congenital or acquired disorders of platelet function. Platelet transfusions are also considered prophylactically in patients with counts <50 000/μL who require invasive procedures including surgery. Random-donor platelets are platelet concentrates prepared from whole blood. Six units of random-donor platelets are pooled into

a single pack to provide an adult dose. The clinical indications for the use of washed, irradiated, and leukoreduced platelets are similar to those described above for RBC transfusions. One pack of platelets will temporarily raise platelet counts by 30 000-60 000/μL. The lifespan is short and may need to be redosed every 3-4 days.

## *Fresh Frozen Plasma*

Fresh frozen plasma (FFP) contains clotting factors, albumin, and fibrinogen. FFP is indicated for the replacement of coagulation factors in patients with deficiencies of multiple clotting factors as seen in disseminated intravascular coagulation and massive transfusions. FFP is indicated only for active bleeding or if there is a risk for bleeding from an emergent procedure. One milliliter of FFP contains one unit of coagulation factor activity. Coagulation tests should be monitored to determine efficacy and appropriate dosing intervals.

## *Cryoprecipitate*

Cryoprecipitate is the cold-insoluble precipitate formed when FFP is thawed at 1-6 °C. It contains 150 mg or more of fibrinogen, 80 IU or more of factor VIII, 40%-70% of vWF, and 20%-30% of factor XIII present in the initial unit of FFP. Each unit (bag) of cryoprecipitate increases fibrinogen level by 5-10 mg/dL. Cryoprecipitate is indicated for the correction of hypofibrinogenemia in dilutional coagulopathy and disseminated intravascular coagulation. Cryoprecipitate also improves platelet aggregation and adhesion and helps decrease bleeding in uremic patients.

## *Treatment of Hemorrhagic Shock*

The most common cause of shock in the obstetric and gynecologic patient is hemorrhage. Goals during the resuscitation of patients in hemorrhagic shock are to achieve replacement of adequate circulating volume while avoiding coagulopathy, hypothermia, progressive acidosis, and excessive crystalloid administration.

Patients with significant hemorrhagic shock may have alterations in their level of consciousness, and an assessment of the safety of their airway and ability to maintain oxygenation should be undertaken and an airway established as required. Two large-bore IVs (18 gauge or larger) should be established to ensure the ability to provide crystalloid and blood products without limitation of flow and cell lysis by the catheter. Efforts should be made to maintain patient normothermia by use of warm fluids, fluid warming devices, heated ventilator circuits with temperature turned to 38 °C-40 °C, forced air warming devices, and setting ambient room temperature to 26.5 °C-29 °C.

Patients with limited blood loss, class I and class II hemorrhagic shock, may respond to crystalloid resuscitation. Specifically, patients with hemorrhage of up to 30% of their blood volume may be treated with crystalloid resuscitation without necessarily requiring blood products, assuming that hemorrhage has been controlled and preexisting ischemic cardiac disease is not present. Patients with blood loss >30% of their volume usually require blood and blood product administration. The approach to transfusion in a patient with hemorrhagic shock with ongoing blood loss should be different than for patients with large volume blood loss without shock. Traditionally, resuscitation for hemorrhage has focused on replacing circulating volume with crystalloid and packed red blood cells (PRBCs). In situations in which blood loss is matched by fluid and blood replacement without limitations in blood flow (isovolemic blood loss), large volumes of blood can be administered without the development of coagulopathy, and other blood products like FFP, cryoprecipitate, and platelets should be administered based upon abnormal laboratory analysis. However, the presence of shock and tissue hypoxia contributes to coagulopathy, and empiric treatment with other components may be indicated. Data predominately from civilian and military trauma literature support an approach in patients with massive hemorrhage that limits crystalloid resuscitation and provides replacement of blood products approximating a 1:1:1 ratio of PRBCs, FFP, and platelets. To achieve this, most centers have developed massive transfusion protocols to provide the correct ratios of products. The use of massive transfusion protocols should be

considered in patients with ongoing hemorrhage (or risk of ongoing hemorrhage) and hypotension (systolic blood pressure <90 mm Hg) after initial 2 units of PRBCs. The use of massive transfusion protocols should be considered in a bleeding patient with severe acidosis, existing coagulopathy, thrombocytopenia, or hypothermia. The use and timing of other products such as cryoprecipitate or recombinant factor VII remains controversial and variable in practice. Use of tranexamic acid is becoming popular and has shown decreased mortality when used in obstetric hemorrhage.

# Wound Care

Within hours after a wound is closed, the wound space fills with an inflammatory exudate. Epidermal cells at the edges of the wound begin to divide and migrate across the wound surface. By 48 hours after closure, deeper structures are completely sealed off from the external environment. Sterile dressings applied in the operating room provide protection during this period. If the wound is dry, dressings need not be reapplied after initial removal. Wet dressings should be removed earlier because soaked dressings increase bacterial contamination of the wound. Removal of the dressing and handling of the wound during the first 24 hours should be done with aseptic technique. If skin staples are used, they may be removed by the fifth postoperative day and replaced with Steri-Strip tape. Consider delayed removal of skin staples for incisions that cross creases (eg, groin, popliteal area) or those under tension. And finally, a recent Cochran review of early (within 48 hours after surgery) versus delayed postoperative bathing or showering (over 48 hours after surgery) found no difference in surgical site infections between the two groups.

## *Wound Dehiscence*

Separation of a wound that was primarily closed is referred to as a dehiscence. Risk factors for wound dehiscence include malnutrition, obesity, smoking, infection, and diabetes. Technical errors that increase the risk of dehiscence include poor tissue handling,

excessive tension on the wound, and inappropriate suture choice (material that absorbs too quickly).

Wound dehiscence starts with separation of the wound edges. A fascial dehiscence may start with the overlying skin remaining intact. Weeping of serosanguinous fluid through the incision and erythema of the skin should raise the suspicion of an abdominal fascial dehiscence. A large dehiscence with bowel evisceration is a surgical emergency.

# Venous Thromboembolism

About 3 million venous thrombotic events, or venous thromboembolisms (VTEs), occur in the United States each year. About 2 000 000 plus of these events are deep vein thrombosis (DVT) in the hospital with ~250 000 fatal PEs and 230 000 nonfatal PEs. More than 90% of PE patients have a lower or upper extremity DVT concomitantly. VTE has been recognized as the biggest preventable cause of morbidity and mortality in U.S. hospitals. Ten percent of hospital deaths in the United States are due to PE. Patients with cancer have a higher-than-usual risk for VTE, with a general incidence of about 15%-20%. With no prophylaxis, the risk of fatal postoperative PE among these patients may be as high as 40%. VTE prevention is reviewed in Chapter 2.

## *Diagnosis of VTE*

The clinical presentation of a VTE varies based on the location and extent of the thrombus. The cardinal signs and symptoms of a DVT are pain, warmth, or asymmetrical swelling of an extremity. In high-risk patients, such as those who are obese or pregnant or have cancer, other less typical postoperative complaints should be carefully evaluated. PE has few defining characteristics. The onset of respiratory distress compounded by hypotension, chest pain, and cardiac arrhythmias should be considered potential evidence for a PE and may potentially be harbingers of impending death. Only 70% of patients who die of a PE have it considered in their differential

diagnosis because symptoms are nonspecific and may mimic other pulmonary/cardiac conditions.

Diagnostic efforts in radiology are aimed at (1) reaching an acceptable level of diagnostic certainty of PE to warrant anticoagulant therapy, using the least-invasive tests, and (2) excluding other reasons for the patient's symptoms. Historically, the posttest probability of a patient having PE was calculated by combining the pretest likelihood of the condition (PE) and modifying the results of the appropriate radiological procedure(s). This approach has evolved over the last decade. Clinical decision trees using the Wells criteria and revised Geneva Score (**TABLE 11.10**) have been developed and validated in nonsurgical patients. There have also been major diagnostic advances, primarily in CT and magnetic resonance imaging. Many studies have evaluated these modalities and the use of imaging in conjunction with clinical criteria and serum assay for D-dimer (**FIG. 11.2**). High-sensitivity D-dimer testing has improved the specificity of the diagnosis of PE. However, the value of this test is reduced in the perioperative period, as D-dimer levels will be elevated with any significant thrombotic process (eg, pregnancy, recovery from surgery, and status post trauma). In patients determined to be at high risk of PE by validated clinical criteria, D-dimer assays add little new information. In all other settings, a negative D-dimer test effectively excludes PE or DVT.

## TABLE 11.10
## Prediction of Pulmonary Embolism Using the Revised Geneva Score

| RISK FACTORS | POINTS |
|---|---|
| **Patient Characteristics** | |
| Age older than 65 | 1 |
| Previous DVT or PE | 3 |
| Surgery under general anesthesia within 1 mo | 2 |
| Active malignant condition (currently active or considered cured <1 y) | 2 |
| **Symptoms** | |
| Unilateral lower limb pain | 3 |
| Hemoptysis | 2 |
| ***Clinical Signs*** | |
| Heart rate 75-94 beats/min | 3 |
| Heart rate >95 beats/min | 5 |
| Pain on lower limb deep venous palpation or unilateral edema | 4 |
| **CLINICAL PROBABILITY** | **TOTAL SCORE** |
| Low | 0-3 |
| Intermediate | 4-10 |
| High | 11 or greater |

Adapted from Le Gal G, Righini M, Roy PM, et al. Prediction of pulmonary embolism in the emergency department: the revised Geneva score. *Ann Intern Med*. 2006;144(3):165-171. Copyright © 2006 American College of Physicians. All Rights Reserved. Reprinted with the permission of American College of Physicians, Inc.

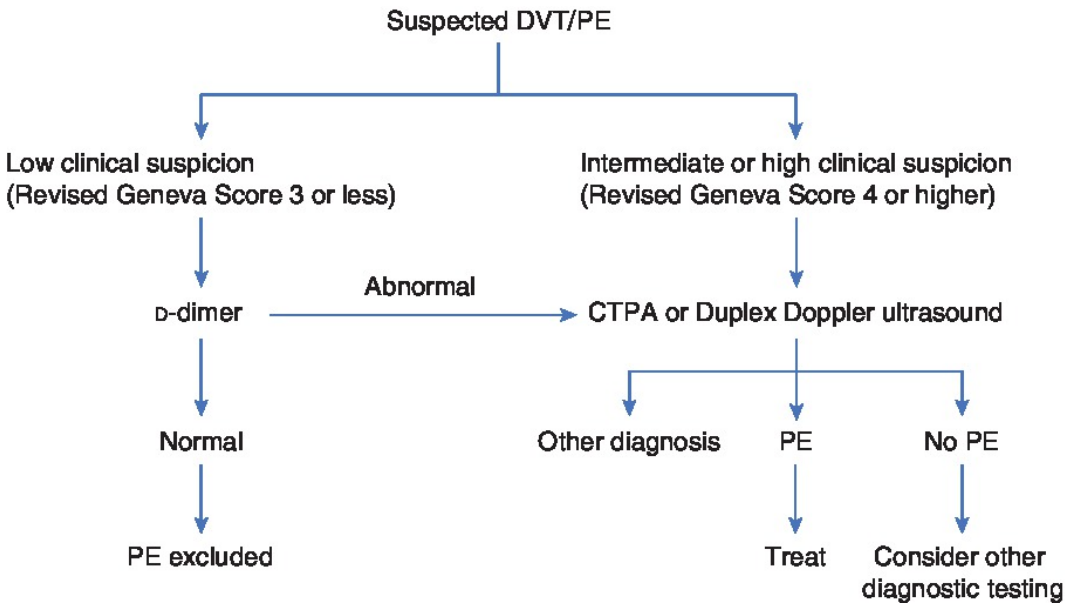


**FIGURE 11.2** Proposed diagnostic algorithm for a suspected deep venous thrombosis or pulmonary embolism (DVT/PE). (Adapted from Bates SM, Jaeschke R, Stevens SM, et al. Diagnosis of DVT: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2 suppl):e351S-e418S; Ryu JH, Swensen SJ, Olson EJ, et al. Diagnosis of pulmonary embolism with use of computed tomographic angiography. *Mayo Clin Proc*. 2001;76(1):59.)

## Chest Radiograph

The posteroanterior and lateral chest radiograph are important initial studies in the evaluation of presumed PE. Discovery of an alternate reason for acute symptoms, such as pneumonia or a large effusion,

can eliminate the need for additional radiographic procedures. Conversely, a normal chest radiograph does not exclude PE.

## Duplex Doppler Ultrasound

This is a combination technique using real-time and Doppler methods in a procedure known as B mode or duplex Doppler imaging. A vessel with a thrombus in it can be visualized. The high sensitivities and specificities of duplex B mode imaging have made it the noninvasive imaging method of choice, essentially replacing venography as the “practical” gold standard for the diagnosis of DVT.

Because of the high association of DVT with PE, duplex Doppler ultrasound of the lower extremities may be indicated in the evaluation of a patient with suspected PE, especially in patients with signs and symptoms of DVT. The presence of DVT does not guarantee the presence of a PE but increases its likelihood. Also, positive DVT studies may identify patients at higher risk for subsequent PE. In most patients, however, DVT and PE are treated identically, so when DVT is identified, no further diagnostic evaluation for PE is needed. A negative extremity duplex Doppler ultrasound study does not exclude PE, although it significantly decreases its likelihood.

## Computed Tomography

Multidetector CT pulmonary angiography (CTPA) is now the primary imaging modality for evaluating patients suspected of having acute PE. CTPA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations. The overall accuracy of CTPA appears to be very high and is even higher when combined with clinical assessment and serum D-dimer testing. A positive CTPA result combined with high or intermediate suspicion on clinical assessment has a high positive predictive value.

## Magnetic Resonance Venography

Magnetic resonance venography may be a valuable alternative in patients where ultrasonography was inconclusive and DVT could not be ruled out. Compared to CTPA, magnetic resonance imaging provides the theoretic advantage of avoiding both ionizing radiation and IV contrast. While a 2015 meta-analysis estimate sensitivity and specificity for DVT around 93% and 96%, respectively, the quality of the included studies warrant caution, and the modality has not been validated in a management study. It may remain beneficial for specific populations where ultrasonography is not feasible, such as morbidly obese patients.

# *Treatment of Venous Thromboembolism*

Unless there is a contraindication, anticoagulation should be considered for a suspected VTE. Therapeutic considerations are broken up into three phases—initiation (within 21 days of initial VTE diagnosis), treatment (3 months after acute VTE), and extended (beyond 3 months). Among individuals at high risk for VTE recurrence, extended treatment is recommended for secondary prevention.

In the past 5 years, there have been substantial updates to the recommended management strategies. Traditional anticoagulant options include unfractionated heparin, low molecular weight heparin, fondaparinux, and warfarin. The new direct oral anticoagulants (DOACs) provide additional options. Choice of anticoagulant depends on indications, the patient's underlying conditions, and risk of future bleeding.

## Anticoagulant Options

***Unfractionated Heparin.*** Unfractionated heparin can be used for the prevention and initial treatment of acute VTEs. The short elimination half-life (~1 hour), ability to fully reverse, and safety in use in patients with renal failure are the advantages of unfractionated heparin. However, the risk of heparin-induced thrombocytopenia is 8- to 10-fold higher with unfractionated heparin versus low molecular weight heparin.

***Low Molecular Weight Heparin.*** In the United States, enoxaparin (Lovenox) is the most commonly used low molecular weight heparin. Subcutaneous administration is weight based and indicated for prevention and initial treatment of acute VTEs. Low molecular weight heparin is also the bridging agent of choice for transitioning to warfarin, dabigatran, or edoxaban. While monitoring is not required, anti-Xa assays can be used if deemed necessary.

***Fondaparinux.*** Fondaparinux is a once-daily subcutaneous injection used for treating acute VTEs in combination with warfarin, dabigatran, or edoxaban. Severe renal failure and bacterial endocarditis are contraindications to the use of fondaparinux. The long half-life (~17-21 hours) and lack of reversal agents have limited its use in clinical practice.

***Warfarin.*** Warfarin, a vitamin K antagonist, was classically the agent of choice for long term and extended treatment of VTEs. Dosing for oral administration requires close monitoring of international normalized ratio of prothrombin time (INR/PT). DOACs have increasingly replaced warfarin for long-term anticoagulation.

***Direct Oral Anticoagulants.*** The newer class of anticoagulants, DOACs, is attractive alternatives to warfarin for the treatment of VTEs. Multiple RCTs have shown DOACs to be noninferior to warfarin and, therefore, these medications are now recommended by the ACCP for long-term treatment of VTEs. The major advantages of DOACs over warfarin include fewer drug-drug interactions, oral administration that may not require bridging treatment, no need for INR/PT monitoring, and fixed dosing with rapid onset of action.

Rivaroxaban (Xarelto) and apixaban (Eliquis) are direct factor Xa inhibitors, which can be used as monotherapy for the initial treatment of VTE. The EINSTEIN PE trial found rivaroxaban to be as effective as warfarin for the treatment of symptomatic PE. There does appear to be a slight increased risk of GI bleeding in patients over 75 with rivaroxaban, whereas apixaban has not been associated with similar issues.

Dabigatran (Pradaxa) and edoxaban (Savaysa) are direct thrombin inhibitors. In a large meta-analysis, dabigatran appears to be as effective as warfarin in the short- and long-term treatment of

DVTs but does have increased risk of GI bleeding in patients with atrial fibrillation and increased risk of MI or acute coronary syndrome. Both dabigatran and edoxaban require a 5- to 7-day bridge with parenteral anticoagulation. Dabigatran is currently the only DOAC with an anticoagulant-reversing agent (idarucizumab).

## Medical Management of VTE

In 2021, the second update to the 9th edition of the CHEST Guidelines on antithrombotic therapy for VTE reviewed the new evidence that emerged since 2016. The expert panel provided recommendations on 17 PICO question and generated 29 guidance statements, 13 of which are graded as strong recommendations. A few key recommendations relevant for Ob/Gyn's include the following:

- **In patients with an acute VTE in the setting of cancer-associated thrombus, oral Xa inhibitors (apixaban, edoxaban, rivaroxaban) are recommended over LMWH for initiation and treatment phase of therapy.**
- All patients with an acute VTE and no contraindication should receive 3-month treatment phase of anticoagulation.
- Extended phase anticoagulation is not recommended for patients with a VTE diagnosed in the setting of a major transient risk factor (surgery under general anesthesia >30 minutes or hospitalization for at least 3 days). This recommendation should be balanced with patient preference and predicted risk of recurrent VTE or bleeding. Patients on extended phase anticoagulation should have the decision reevaluated at least on an annual basis and at times of significant changes in health status.

## Surgical Management of VTE

IVC filters are overused in the United States. This approach should be reserved for patients with an acute VTE and an absolute contraindication to anticoagulation (active major bleed, severe

thrombocytopenia, high bleeding risk, central nervous system lesion).

## KEY POINTS

- Postoperative morbidity can be minimized by a thorough preoperative assessment of the surgical patient with appropriate perioperative management of risk factors.
- Multimodal pain strategies should be implemented to enhance recovery and minimize the use of opioids.
- Early feeding (<24 hours) accelerates GI recovery and decreased the hospital length of stay.
- IV fluids should be discontinued in the early postoperative period, and clear fluids should be encouraged as tolerated soon after surgery.
- In the absence of an obvious source, the development of postoperative pulmonary edema should be regarded as evidence of sepsis.
- VTE has been regarded as the biggest preventable cause of morbidity and mortality in U.S. hospitals. Risk-based stratification of patients can help guide the most appropriate VTE prophylactic regimen.
- Oral Xa inhibitors (apixaban, edoxaban, rivaroxaban) are recommended over LMWH for the initiation and treatment phase of treating an acute cancer–related VTE.

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# CHAPTER 12

# POSTOPERATIVE INFECTIONS IN GYNECOLOGIC SURGERY

Anna Powell

**Risk Factors for SSI**
Patient-Level Risk Factors
Procedure-Level Risk Factors
**Evaluation of Surgical Site Infection**
Fever Evaluation
Physical Examination
Laboratory Testing
Imaging
**Postoperative Infection Outside the Surgical Site**
Urinary Tract Infection
Pneumonia
*Clostridium difficile* Colitis
**Treatment of Surgical Site Infection**
Superficial/Incisional Infection
Deep Incisional Surgical Site Infections
Organ Space Infections
Necrotizing Infections
Vaginal Cuff Infection

## Treatment of Vulvar Infections

## Antibiotic Hypersensitivity

Surgical site infection (SSI) is the most common complication of surgery in the United States. SSIs account for 29% of readmissions following hysterectomy. Surgical site infections cost an average of $5000-$10 000 per infection and $7 billion per year in health care spending. Patients experiencing SSIs are 60% more likely to spend time in an intensive care unit and have 2-11 times higher risk of death compared to those without an SSI. Up to 60% of SSIs are thought to be preventable. Therefore, examining methods to prevent SSI will help to decrease morbidity and mortality risk to patients undergoing gynecologic surgery.

Most benign gynecologic surgery falls under the classification of “clean” or “clean-contaminated” surgery according to Centers for Disease Control and Prevention (CDC) guidelines for classification of surgical wounds. “Clean” gynecologic surgery is characterized by uninfected operative wounds in which no inflammation is encountered and in which the vagina is not entered. In contrast, “clean-contaminated” surgical procedures involve the vagina but without major breaks in sterile technique, gross spillage from the gastrointestinal (GI) tract, or evidence of infection.

Various organizations have proposed systems for defining, categorizing, and reporting SSI. The National Healthcare Safety Network is a voluntary surveillance system developed by the CDC to track hospital-acquired infections. Definitions in use by CDC are listed in **TABLE 12.1**. The Joint Commission’s Surgical Care Improvement Project was launched in 2006 in order to decrease SSI rates. However, despite this program, SSI rates have not seen a dramatic decrease. Given this ongoing issue, the Council on Patient Safety in Women’s Health Care (convened by ACOG) formed a workgroup of subject matter experts to develop a consensus bundle of best-practice guidelines to address SSI prevention on an institutional level, which was ultimately concluded in August 2021. Its execution is geared toward a multidisciplinary effort for medical

professionals involved in gynecologic surgery, including the gynecologist, anesthesia, and nursing teams. Recommendations put forward by the panel will be reviewed throughout this chapter.

## TABLE 12.1
## SSI Classification (Defined as Infection Within 30 Days of Operative Procedure)

| INFECTION SITE | DESCRIPTION |
|---|---|
| Superficial/incisional | Involves only skin and subcutaneous tissues, and the patient has at least one of the following:<br>• Purulent drainage from the superficial incision<br>• Organisms identified from an aseptically collected specimen, performed for the purpose of clinical diagnosis or treatment<br>• Superficial incision that is intentionally opened in the presence of patient symptoms (pain, localized swelling, erythema, or heat) |
| Deep incisional | Involves deep soft tissues of the incision (fascia, muscles), and the patient has at least one of the following:<br>• Purulent drainage<br>• Spontaneous wound dehiscence or deliberate wound opening by surgeon where an organism is identified by microbiologic testing for the purpose of clinical diagnosis and treatment in the setting of patient symptoms (fever >38 °C, localized pain or tenderness)<br>• An abscess or other evidence of infection identified in the deep incision by imaging |
| Organ space | Involves any part of the body deeper than muscle or fascial layer, and the patient has at least one of the following:<br>• Purulent drainage from a drain placed into the organ space<br>• Organisms are identified from aseptically obtained fluid or tissue in the organ space by microbiologic testing for the purpose of clinical diagnosis or treatment<br>• An abscess or other evidence of infection involving the organ space detected on gross anatomical, histopathologic examination or by imaging<br>• Meets at least one criterion for a specific organ space infection; in the case of hysterectomy, this may be vaginal cuff cellulitis or abscess |

Systematic review of SSI cases on both a departmental and an institutional level is an important component of quality improvement. In addition to postoperative outcome evaluation, each facility should consider preoperative review of high-risk surgical patients and create a system for tracking, reporting, and analyzing SSI to facilitate outcomes and metrics processing. Preoperative review of high-risk patients may help decrease communication failures, which are often leading causes of sentinel SSI events. Having an active SSI monitoring system facilitates problem identification and change implementation. A variety of metrics may help track patient outcomes, such as tracking the percentage of patients receiving the correct antibiotic prophylaxis, timing, appropriate postoperative discontinuation, and patient education on wound care.

# RISK FACTORS FOR SSI

Among hysterectomies, the abdominal approach is associated with almost twice as many SSI events as minimally invasive routes. For abdominal hysterectomy procedures, risk factors associated with SSI include older age, diabetes, body mass index (BMI), American Society of Anesthesiologists (ASA) score, medical school affiliation, smaller hospital bed size/lower surgical volume facilities, procedure duration, and whether or not the surgery was performed for malignancy. Additional patient-level and procedure-level risk factors are reviewed in the section that follows and summarized in **TABLE 12.2**.

## TABLE 12.2
## Best Surgical Practice Techniques to Reduce SSI Risk

| TIMING | BEST SURGICAL PRACTICE TECHNIQUES |
|---|---|
| Preoperative | Assessment and optimization of patient's risk factors for surgery:<br>• Type of surgery (clean, clean-contaminated, contaminated)<br>• Glycemic control<br>• Management of obesity<br>• MRSA status<br>• Immune status<br>• Smoking cessation |
| Intraoperative | • Appropriate antimicrobial prophylaxis (regarding choice and timing of administration)<br>• Minimizing operative duration<br>• Normothermia<br>• Hemostasis |
| Postoperative | • Correction of anemia<br>• Glycemic control<br>• Systematic review of SSI cases on departmental/institutional level to improve SSI rates |

# Patient-Level Risk Factors

## *Weight/Obesity*

Obesity is associated with increased SSI risk. When prophylactic perioperative antibiotics are selected, obese patients may require increased antibiotic dosing. Several studies have investigated the pharmacokinetics of preoperative antibiotics in obese patients to ensure appropriate tissue levels. Historically, patients with a BMI > 35 $kg/m^2$ given intravenous cefazolin were found to have significantly lower serum and adipose tissue levels compared to

nonobese patients; therefore, the 2-g dose is recommended for patients weighing <120 kg and a dose of 3-g cefazolin is recommended for patients weighing >120 kg.

Risk of SSI has been independently correlated with depth of subcutaneous wound; in a meta-analysis by Chelmow et al. (2004), subcutaneous tissue closure decreased SSI risk by 34% for patients with subcutaneous tissue depth >2 cm. One additional benefit of subcutaneous closure was decreased postoperative wound seroma, a risk factor for SSI.

Nag et al. investigated panniculectomy as an adjunct to gynecologic surgery. There was speculation that panniculectomy would reduce the depth of the operative field, facilitate exposure, and provide greater control of abdominal viscera. Data from the American College of Surgeons National Surgical Quality Improvement Program demonstrated that 296 obese patients undergoing the joint procedures experienced significantly higher incidence of superficial infection compared to hysterectomy alone (10.5% vs 4.5%, *P* = .001) and also a higher incidence of wound infection (2.4% vs 54%, *P* = .0014). Thus, panniculectomy appears to increase rather than decrease SSI.

## *Antibiotic-Resistant Skin Flora: Methicillin-Resistant Staphylococcus aureus*

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are relatively rare following gynecologic procedures. However, in a study of SSI rates for patients undergoing hysterectomy for endometrial cancer, history of MRSA colonization was associated with a significant increase in odds for SSI (relative odds 12.4; 95% confidence interval [CI] 1.2-127.3). A prospective, interventional cohort study using a crossover design compared rapid screening for MRSA plus standard infection control to standard infection control alone. Five percent of the screened participants tested positive for MRSA (*n* = 515), and none of the 115 who were identified preoperatively and treated with the appropriate antibiotic prophylaxis

with activity against MRSA developed postoperative infections with MRSA. While some studies support MRSA coverage (should it be identified in the surgical patient preoperatively), universal screening for MRSA is neither currently recommended nor cost-effective for gynecologic surgery. Universal MRSA decolonization is not currently supported in the literature for gynecologic patients. While recent studies have confirmed that *S aureus* decolonization of the anterior nares decreases SSI rates in surgical patients, this appears to be particularly salient in those undergoing cardiac or orthopedic surgeries. The surgeon should consider perioperative prophylaxis with a regimen containing vancomycin for patients undergoing gynecologic surgery in the setting of current or prior MRSA colonization or infection.

# *Smoking*

Smoking has been shown to increase the risk of postoperative wound complications. The relative odds of SSI are 1.79 (95% CI 1.57-2.04) in smokers compared to nonsmokers. Sorensen et al. created a wound healing model in 78 healthy smokers vs nonsmokers by placing four sutured incisions lateral to the sacrum and observing for 15 weeks. Among smokers, 12% developed an SSI compared to 4% of nonsmokers. Subjects who quit smoking at least 4 weeks before surgery had a decreased risk of SSI development. Patients should be counseled about smoking cessation and should be advised to quit smoking several weeks prior to surgery.

# *Bacterial Vaginosis*

Bacterial vaginosis (BV) is a mixed anaerobic overgrowth of the vaginal microbiome contributing to symptomatic discharge and affects about 30% of reproductive-age women in the United States. Most patients with BV, however, are asymptomatic. This condition is associated with an increased risk for vaginal cuff SSI. The relative risk for SSI in the presence of BV is 3.2 (1.5-6.7). Kristiansen et al. obtained cervical cultures for *Gardnerella vaginalis* immediately prior

to vaginal preparation with 2.5% iodine douche from patients undergoing abdominal hysterectomy for benign indications. *G vaginalis* was recovered from 78% of patients who later developed postoperative inflammation (suspected postoperative infection within 6-8 weeks following surgery) and from 9% among patients with negative cultures ($P$ = .001).

Antibiotic prophylaxis at the time of hysterectomy has not traditionally included coverage for anaerobic bacteria. The addition of anaerobic coverage is supported by a large retrospective cohort study from the Michigan Surgical Quality Collaborative. Those investigators found that prophylaxis with cefazolin alone was associated with a significantly higher odds for SSI after hysterectomy vs prophylaxis with cefazolin plus metronidazole (adjusted OR [aOR] 2.30, 95% CI 1.06-4.99). This study was performed in the setting of routine preoperative antibiotic administration and reported an overall SSI rate of 1.8%.

### *Immune Deficiency*

In a retrospective cohort of 77 patients living with HIV who underwent hysterectomy, 58% of subjects met AIDS-defining criteria. While overall SSI rates were high (22%), preoperative CD4 counts were not associated with SSI (aOR 0.99, 95% CI 0.99-1.0).

## Procedure-Level Risk Factors

### *Skin Preparation at Home*

In many centers, patients are instructed to perform a preoperative chlorhexidine shower at home prior to surgery. However, a Cochrane review from 2015 concluded that no clear benefit was seen to using chlorhexidine over other wash products. One large study found a significant difference in favor of chlorhexidine (RR 0.36, 95% CI 0.17-0.79). An important limitation to the interpretation of these results is that preoperative washes were not standardized and among the trials. Thus, there were likely inconsistencies between the interventions and control procedures. Subsequently, a single-

institution retrospective analysis considered a full-body preoperative preparation applied by patients at home the morning of surgery (Nose-to-Toes; Sage Products-Stryker Corporation, Cary, IL). This full-body preoperative preparation included skin cleansing with 2% chlorhexidine wipes, oral cleansing with 0.12% chlorhexidine mouth rinse, and nasal antisepsis with 5% povidone-iodine swabs. For gynecologic procedures, SSI was observed after 3 (2.2%) of 135 patients who participated in the full-body preparation vs 10 (7.4%) of 135 controls.

Recent recommendations by the American College of Obstetricians and Gynecologists advise a full body shower or bath with soap or an antiseptic agent the night before abdominal surgery. We recommend that patients shower with a chlorhexidine preparation on the evening before and the morning of their surgery.

## *Skin Preparation in the Operating Room*

For surgical abdominal preparation, 4% chlorhexidine gluconate plus alcohol is favored over povidone-iodine. In a large retrospective cohort, Uppal et al. found that preoperative cleansing of skin with chlorhexidine-alcohol was associated with 44% lower odds of developing SSIs after total abdominal hysterectomy (aOR 0.56, 95% CI 0.37-0.85, *P* = .01). Recent recommendations by the American College of Obstetricians and Gynecologists suggest that an alcohol-based agent is recommended for skin preparation.

In addition to abdominal skin preparation, vaginal and perineal preparations are recommended to decrease SSI associated with hysterectomy. Perioperative perineovaginal preparation and abdominal skin preparation should be accomplished with separate kits and applicators, even if the same antiseptic product is used.

Limited data guide recommendations for vaginal preparation prior to hysterectomy with povidone-iodine or chlorhexidine. An RCT of 85 patients compared 4% chlorhexidine to 10% iodine for presurgical vaginal preparation before total vaginal or laparoscopic hysterectomy with a primary outcome of number of positive bacterial cultures at 90 minutes. Chlorhexidine demonstrated fewer positive cultures at 90 minutes (47.6% vs 85.4%; OR 10.6, *P* = .001) with no SSIs

diagnosed in either group. A 2009 retrospective cohort from a Swedish patient registry found no difference between the two vaginal preps regarding decreasing postoperative infections following abdominal or vaginal hysterectomy. Interestingly, a saline vaginal preparation was associated with a higher risk of immediate postoperative infections (particularly urinary tract infections). Kjolhede et al. found no significant differences in postoperative infectious morbidity following vaginal hysterectomy preceded by no vaginal prep, saline, or chlorhexidine preparation.

Skeith et al. undertook a retrospective analysis of patients undergoing hysterectomy at 70 hospitals in a statewide surgical collaborative with the primary outcomes being postoperative infectious complications (including SSI) within 30 days of surgery. Propensity score matching was used to analyze 2935 pairs of patient exposures to povidone-iodine and chlorhexidine among other covariates; povidone-iodine was associated with a lower rate of infectious morbidity (3.0 vs 3.4%, *P* = .01) and nonsignificant trend of lower SSI rate (2.0% vs 2.7%, *P* = .07) compared to chlorhexidine.

# *Perioperative Antibiotics*

Randomized controlled trials support the use of preoperative antibiotics for selected classes of gynecologic surgery. Antimicrobial prophylaxis used preoperatively for the prevention of SSI should meet the following criteria: safe to use/low toxicity, not used routinely for treatment, has an appropriate spectrum of activity, gains useful concentrations in relevant tissues, has short duration, and its administration is convenient to the surgical suite. On this basis, β-lactams are generally preferred (see TABLE 2.4, “Antimicrobial Prophylactic Regimens by Procedure”). Prophylaxis with β-lactam antibiotics is associated with reduction in the incidence of postoperative SSIs.

For patients with immediate hypersensitivity reaction to β-lactam antibiotic, alternative regimens may be considered. It is important to clarify true β-lactam hypersensitivity vs intolerance, as Uppal et al. showed that alternative regimens had increased odds for SSI (OR 1.7, 95% CI 1.27-2.07) compared to standard β-lactam regimens.

Timing of perioperative antimicrobial prophylaxis administration is of critical importance. Administration should ideally occur within 60 minutes of skin incision and no later than 15 minutes prior to skin incision or 120 minutes prior to skin incision for those agents requiring slower infusion times. This practice allows for adequate serum and tissue concentrations to be present at the time of skin incision. Timing after 120 minutes vs 0-30 minutes prior to skin incision was associated with an SSI rate of 4.7% compared to 1.6%.

Classen et al. (1992) further evaluated the importance of appropriate timing of perioperative antibiotics. Postoperative antibiotic administration (>3 hours following incision) was associated with the highest risk for SSI (OR 5.8, 95% CI 2.4-13.8, *P* = .0001), followed by preoperative administration more than 2 hours prior to skin incision (OR 4.3, 95% CI 1.8-10.4, *P* = .001). Antimicrobial prophylaxis should not be continued postoperatively.

During surgery, antimicrobial prophylaxis should be redosed in the setting of excessive intraoperative blood loss (>1500 mL) or prolonged operative time (>4 hours). The half-life of cefazolin is 1.8 hours, so a second dose should be administered if the surgical time is approaching 4 hours. Surgical blood loss has been correlated with tissue cefazolin concentration and with blood loss >1500 mL, tissue antibiotic concentrations significantly declined.

# *Normothermia*

General anesthesia dramatically impacts thermoregulation during surgery. Volatile inhalational anesthetics, propofol, and opioids impair thermoregulatory mechanisms, causing a peripheral body heat redistribution. Central hypothermia increases vasoconstriction, leading to decreased tissue oxygenation and impaired local immune function. Kurz et al. (2008) demonstrated that the SSI rate decreased from 19% to 6% with maintenance of normothermia. Multiple methods can be used to maintain normothermia, including forced heated air around the patient and warmed IV fluids. As warmer ambient operating room temperatures can cause discomfort for the surgical team, the warmer room temperature should be maintained initially during anesthesia induction, followed by a

decrease for the case start. The patient's core body temperature should be maintained at more than 36.5 °C.

# *Duration of Surgery*

Duration of surgery is an important risk factor for SSI and is included in the National Nosocomial Infection Surveillance risk index. In a review of National Surgical Quality Improvement program data, Mahdi et al. found that abdominal hysterectomy duration exceeding 180 minutes increased the odds of SSI by 1.8 (95% CI 1.2-2.6; *P* = .002) and laparoscopic hysterectomy lasting more than 180 minutes increased SSI odds by 2.2 (95% CI 1.01-.9; *P* = .005). Pop-Vicas et al. reviewed outcomes among 1531 hysterectomies (including those performed for gynecologic malignancies), finding that longer surgical duration increased odds of SSI by 3.5 (95% CI 1.21-9.76, *P* = .02), after adjustment for weight, median Charlson comorbidity index, immunosuppressed state, ASA ≥ 3, prior procedure within last 60 days, robotic or laparoscopic hysterectomy, bowel involvement, ≥4 surgeons present or 7 catheters/invasive devices, and preoperative antibiotic choice (cefazolin or clindamycin/gentamicin).

# *Abdominal Closure Protocol*

Closure of the abdominal wound with unused sterile instruments has been proposed. Kwaan et al. (2016) investigated this question by comparing the use of unused sterile instruments and equipment for fascial closure compared to usual care. Overall, there was no significant difference in 30-day SSI rates, with 11.6% in the protocol group compared to 12.4% with usual care (*P* = .85).

The role of negative pressure wound therapy (NPWT) has been explored to decrease SSI rates. NPWT is thought to decrease subcutaneous tissue fluid collection and seroma formation. However, there is conflicting evidence supporting use of an NPWT device in patients at high risk for postoperative wound complications. A recent systematic review and meta-analysis of 11 RCTs with 4112 patients (2057 with negative pressure wound dressings and 2055 with standard dressing) showed significantly decreased SSI rates (OR

0.76, 95% CI 0.61-0.94, *P* = .01) in patients receiving NPWT intervention. There were no differences in rates of incision dehiscence, seroma formation, or readmission between groups.

### *Perioperative "Bundle" to Reduce SSI*

Johnson et al. developed a perioperative "bundle" of interventions, designed to reduce SSI after gynecologic cancer surgery. These interventions included patient education, 4% chlorhexidine gluconate shower prior to surgery, washing the abdomen with a chlorhexidine cloth on the morning of surgery; antibiotic administration within 1 hour of skin incision; 2% chlorhexidine gluconate/70% isopropyl alcohol skin preparation of the incisional area; repeating the administration of cefazolin 3-4 hours following incision; sterile closing tray, staff glove change for fascial and skin closure; dressing removal after 24-48 hours; hospital discharge with 4% chlorhexidine gluconate for initial shower following dressing removal as well as a nursing phone call. The group identified a relative risk reduction for SSI of 82.4% (*P* = .01) overall, compared to historical controls. While it is difficult to isolate the exact impact of each component of the protocol in this particular study, these interventions warrant further investigation in the setting of gynecologic surgery outside of gynecologic oncology.

# EVALUATION OF SURGICAL SITE INFECTION

## Fever Evaluation

A postoperative fever is typically defined as a temperature of 38 °C (100.4 °F) on two occasions at least 4 hours apart, or a single temperature ≥39 °C. Febrile morbidity is the most common reported adverse event following hysterectomy; immediate postoperative fever occurs with an estimated incidence of 31%-50%. While not all postoperative fevers indicate infection, fever outside of the initial 24 hours postoperation requires further evaluation. In a retrospective

study by Fanning et al., <10% of gynecologic patients who developed a postoperative fever had an identified infectious etiology. Fever represents a physiologic manifestation of infection or inflammation. Inflammation and macrophage phagocytosis of extravasated blood are common and benign postoperative events implicated in the febrile response to surgery. Up to 72% of postoperative fever cases occur within the first 48 hours (**TABLE 12.3**).

## TABLE 12.3
## Differential Diagnosis for Postoperative Fever

| ORGAN/SYSTEM | POTENTIAL CAUSE OF POSTOPERATIVE FEVER | TYPICAL POSTOPERATIVE TIMING | CLINICAL APPROACH |
|---|---|---|---|
| Central nervous system | Drug fever | Any | Review medication list and potential interactions; discontinue suspected medication |
| Respiratory | Pneumonia | <48 h | Incentive spirometry, early mobilization, pulmonary toilet, chest radiography, sputum culture, antibiotics |
| Cardiovascular | Deep vein thrombosis<br>Septic pelvic thrombophlebitis | >72 h<br>>72 h | Compression ultrasonography, anticoagulation |
| | Hematoma | Any | Additional imaging including CT scan or MRI; drainage if collection is large/accessible |
| | Blood transfusion reaction | Immediate—24 h following transfusion | Antihistamine administration, discontinue transfusion |
| Genitourinary | Urinary tract infection | >48 h | Removal of catheter, urinalysis, urine culture, antibiotics |
| Infectious | Surgical site infection<br>Abscess<br>Bacteremia<br>Sinusitis<br>Infected hematoma | >72 h | |
| Iatrogenic | Catheter-related infection | Any | Removal of infected catheter |
| Psychiatric | Withdrawal/delirium tremens | >72 h | Review of patient's history and substance use, consultation with psychiatry, benzodiazepine administration |

Peipert et al. found that fever was more common after abdominal hysterectomy vs other routes (aOR 2.7, 95% CI 1.6-4.3) and was associated with blood loss at surgery >750 mL (aOR 3.5, 95% CI 1.8-6.8). Both of these factors increased risk of fever following hysterectomy after controlling for age, BMI, operative time, and prophylactic antibiotic administration.

A thorough history will help guide further assessment and workup. Relevant aspects of the history include risk factors for SSI, such as the patient's medical comorbidities, BMI, type of surgery,

MRSA status, surgical wound classification, duration of surgery, and perioperative antimicrobial prophylaxis. Also relevant is the postoperative course to date and any possible surgical complications.

# Physical Examination

Postoperative fever should prompt the surgeon to consider SSI as well as infections in other organ systems including the head, neck, and throat; upper and lower respiratory tracts; cardiovascular system; GI tracts; and urinary tract. The lower extremities should be examined for the possibility of venous thromboembolism. Depending on the timing of fever onset and duration of symptoms, intravenous access points should also be assessed as possible sources of infection. The surgical wound (abdominal or vaginal) should be investigated for signs of seroma, hematoma, cellulitis, or fascial dehiscence. Critical findings may include erythema beyond the immediate borders of suture or staples, expressible or spontaneous drainage, fluctuant masses, or disproportionate pain. Additionally, a pelvic examination should be performed to assist in localizing tenderness. A rectovaginal examination is particularly important in the evaluation of a fluid collection or mass in or near the cul-de-sac. If no obvious source is initially identified, imaging to rule out an intra-abdominal process may be helpful.

# Laboratory Testing

A thorough history and examination of the patient will help guide the necessity for lab work or additional imaging. For example, one proposed algorithm for postoperative fever workup has been proposed by Schwandt et al. (2001). They recommended (1) recording a temperature every 4 hours, (2) evaluating patients with temperature higher than 38 °C (100.4 °F) by history and physical examination, and (3) deferring testing unless abnormal localizing signs or symptoms are present. In this prospective cohort, 27% of patients had postoperative fever after major gynecologic surgery, but only 11% of these febrile patients met criteria for further testing, with

improved yield on test results. Specifically, 100% of chest x-ray films and 80% of urine cultures showed abnormal findings, representing a dramatic improvement in diagnostic probability in comparison to a retrospective cohort (with rates of 6% and 10%, respectively). Few patients (7%) with an evaluation without signs or symptoms were diagnosed with a UTI on the basis of routine lab work alone, suggesting that a more judicious approach to postoperative fever workup will not significantly delay infection diagnosis or treatment.

Within the initial 72 hours following surgery, blood cultures are of low clinical utility. They may be considered in the setting of high fever or persistent fever despite antibiotic administration or if a patient meets criteria for sepsis. For patients meeting the above criteria with a central line in place, at least one blood culture should be drawn through the central line catheter to aid assessment of the catheter's involvement.

If the surgical wound is opened or draining, aerobic and anaerobic bacterial culture collection should be obtained. Empiric antibiotics should be started if other noninfectious causes of fever have been ruled out and then narrowed to cover for the organism identified by culture. For deeper infections such as deep SSI or intra-abdominal abscess, cultures can be ordered from drained specimens to guide further antibiotic therapy.

## Imaging

Ultrasound, CT scan, or MRI can be useful in specific circumstances. Ultrasonography may be useful in the setting of evaluating an abdominal incision for fluid collection, or the pelvis for fluid collection, abscess, or hematoma. CT-based imaging of the abdomen or pelvis can be helpful to diagnose abscess, ureteral, or bowel injury as well as possible pleural fluid collections. CT scan may also be used to guide percutaneous drainage.

# POSTOPERATIVE INFECTION OUTSIDE THE SURGICAL SITE

# Urinary Tract Infection

Urinary tract infection (UTI) is one of the most common hospital-associated infections, and 70%-80% are attributable to indwelling urinary catheters. Up to 16% of hospitalized adults will have a urinary catheter during an inpatient admission. Risk factors for UTI development include duration of catheterization, older age, and not maintaining a closed drainage system. A retrospective study from a tertiary care center identified multiple risk factors for UTI following gynecologic surgery: increasing age (OR 1.33, 95% CI 1.01-1.75), increasing number of procedures (OR 1.42, 95% CI 1.14-1.78), and prolonged voiding dysfunction (OR 3.78, 95% CI 1.66-8.6) were significant. When a UTI is suspected, the indwelling catheter should be removed and catheterized urine culture collected. Empiric antibiotics may be started and changed according to culture results. A urine culture is considered positive if organisms, usually aerobic Gram-negative rods, for example, *Escherichia coli*, are identified at the concentration of $\geq 10^5$ colony-forming units. Upper UTI should be suspected in the setting of fever, UTI, and localizing symptoms (eg, costovertebral angle tenderness to physical examination).

# Pneumonia

Postoperative pneumonia is a hospital-acquired pneumonia or ventilator-associated pneumonia that develops 48-72 hours postoperatively (or following endotracheal intubation). Hospital-acquired pneumonia is the second most common nosocomial infection (following UTIs) and can significantly impact a patient's hospital-associated morbidity and costs. Pneumonia likely develops in the setting of pathogenic replacement of normal host flora in the aerodigestive tract, aspiration of contaminated material and impaired host defense due to critical illness and other risk factors. The host respiratory tract may be susceptible due to exposure to broad-spectrum antibiotics, stress ulcer prophylaxis, and presence of medical devices (endotracheal or nasogastric tubes). Important risk factors identified included age, preoperative sepsis, prolonged operative time (>75th percentile), current steroid use, history of

chronic obstructive pulmonary disease, cancer, dyspnea, >10% weight loss, history of congestive heart failure, and renal failure or dialysis.

Postoperative pneumonia should be considered when a patient develops a new or progressive pulmonary infiltrate with fever, leukocytosis, and productive cough with purulent tracheobronchial secretions. Chest imaging may be helpful in this situation. Hospital-acquired pneumonia in this setting is typically polymicrobial but can mostly be attributed to Gram-negative aerobes. Sputum culture specimens should be obtained when possible to guide further therapy.

## *Clostridium difficile* Colitis

*Clostridium difficile* infection has become one of the most serious nosocomial infections. *C difficile* is a Gram-positive anaerobic bacterium capable for spore and toxin production, producing a variety of clinical manifestations that may include fever, abdominal pain or distension, and watery diarrhea in the postoperative patient. Few data have been reported in the literature specifically addressing the epidemiologic question of *C difficile* infections in postoperative gynecologic patients. Abdelsattar et al. performed a prospective identification of patients with laboratory-confirmed postoperative *C difficile* infection in 0.1% of patients following gynecologic surgery. In multivariable logistic regression, older age, chronic immunosuppression, hypoalbuminemia, and preoperative sepsis were associated with *C difficile* infections while, interestingly, preoperative antibiotics were not. Surgical patients appear to have twice the burden of hospital-acquired infections compared to hospitalized patients on medical services. As expected, postoperative *C difficile* infections significantly increased length of stay, subsequent emergency room evaluations, and readmissions. Health care workers and visitors should observe contact precautions if *C difficile* infection is suspected. Testing for *C difficile* infections should be performed by polymerase chain reaction testing on an unformed stool specimen. Potentially contributing antibiotics should be discontinued while the patient is empirically treated with oral

vancomycin, fidaxomicin, or metronidazole depending on disease severity.

# TREATMENT OF SURGICAL SITE INFECTION

The Infectious Disease Society of America guidelines for soft tissue and skin infections as well as for intra-abdominal abscess provide excellent evidence-based guidelines for the approach to a postsurgical wound infection. Wound infection should be evaluated in the context of fever >4 days following an index surgery in the context of erythema and/or induration to the surgical wound.

Initial treatment consists of opening the wound to obtain “source control.” The surgeon should drain the wound and debride any infected or necrotic material. Fluid from the wound cavity should be sent for Gram stain and culture. Ideally, at least 1 mL of fluid or tissue should be submitted for wound cultures (aerobic/anaerobic). One to ten milliliters of fluid should be directly inoculated into an aerobic blood culture bottle to optimize recovery of aerobic bacteria; at least 0.5 mL of extra fluid is used for Gram stain preparation. Additionally, at least 0.5 mL of fluid or 0.5 g of tissue should be transported for anaerobic culture (or 1-10 mL of fluid directly inoculated into anaerobic blood culture bottle).

Empiric antibiotics should be started while waiting for culture results if temperature is >38 °C, WBC count is >12 000/$mm^3$, and either erythema (>5 cm) or any evidence of necrosis is present (discoloration, presence of eschar, or sloughing of tissue). Early onset of postoperative wound infection may suggest more aggressive pathogens, such as *Streptococcus pyogenes* and clostridia, which can cause rapidly progressive necrotizing postsurgical infections. If either of these organisms is identified or suggested by the Gram stain, the patient should be started on a broad-spectrum antibiotic regimen (see Necrotizing Infections, below) and wound debridement should be performed expeditiously. If infection with *S pyogenes* or clostridia is confirmed, the broad-

spectrum regimen can be narrowed to a penicillin and clindamycin regimen.

## Superficial/Incisional Infection

Signs of superficial wound infections may include erythema, purulent drainage, pain, or swelling. SSIs typically develop after the first 48 hours postoperatively. Patients with surgical site cellulitis without abscess and without evidence of necrotizing fasciitis may typically be treated on an outpatient basis. Inpatient management should be considered for patients with multiple comorbidities or those unable to tolerate oral antibiotic regimens. Superficial SSIs may be treated with a second- or third-generation cephalosporin (such as cefazolin, ceftriaxone, cefoxitin) or a penicillin-β-lactamase inhibitor combination (ampicillin-sulbactam, piperacillin-tazobactam).

## Deep Incisional Surgical Site Infections

In gynecologic surgery, deep incisional SSIs are defined as those that involve muscle or fascia without intra-abdominal abscess formation. Risk factors in multivariate analysis for deeper infections included ASA class ≥3 (aOR 1.81, 95% CI 1.25-2.62), current smoking (aOR 1.99, 95% CI 1.40-2.83), history of cerebrovascular accident with neurologic deficit (aOR 4.41, 95% CI 1.54-12.65), preoperative anemia (aOR 1.72, 95% CI 1.21-2.43), and morbid obesity (aOR 2.23, 95% CI 1.43-3.49).

For deep surgical infections, initial evaluation and management should be considered in the in-patient setting as patients may require parenteral antibiotics. Consideration for hospitalization should be given to patients with temperature >39 °C, inability to tolerate oral antibiotics, hemodynamic instability, or evidence of intra-abdominal abscess or peritonitis.

Whenever possible, fluid collections should be drained in order to decrease the microbial burden of the source of infection. In some cases, this may involve minimally invasive drain placement or taking the patient back to the operating room for a wound debridement and

irrigation. A return to the operating room should not be delayed for critically ill patients. Empiric antibiotic treatment should be used with reservation, and only after attempts at source control, since removal of the infectious source will contribute to improvement of the patient's condition more effectively. Imaging should be considered in the absence of clinical improvement, as interval abscess formation may have occurred. Parenteral antibiotics should typically be continued for 24-48 hours until the patient is afebrile and clinically improving (**BOX 12.1**).

### BOX 12.1 RECOMMENDED EMPIRIC ANTIBIOTIC REGIMENS FOR DEEP SURGICAL SITE INFECTIONS INVOLVING PERINEUM, GI TRACT, OR FEMALE GENITAL TRACT

- Cephalosporin plus metronidazole
- Levofloxacin plus metronidazole
- Carbapenem alone

For deep infections resulting from surgery involving the perineum, GI tract, or female genital tract, recommended empiric antibiotics are listed in **BOX 12.1**. Gentamicin plus clindamycin is a very commonly used regimen for obstetric or gynecologic infections. However, clindamycin is not recommended as a first-line agent in the setting of intra-abdominal abscess due to rising antibiotic resistance from *Bacteroides fragilis*, a coliform frequently identified in intra-abdominal infections.

## Organ Space Infections

Organ space SSIs may include adnexal infections or pelvic abscess. Pelvic abscess formation complicates about 1% of gynecologic surgery and is thought to occur following superinfection of accumulated blood, lymphatic and serous fluids, necrotic debris within the lower pelvis in the area of the vaginal vault as a result of

ascending infection through the vagina, or skin or bowel contamination.

For *organ space infections* or *intra-abdominal infections*, the overall principle of source control should similarly drive management. Source control refers to reducing or removing the source of infection in order to expedite response to antibiotics and recovery. This is particularly important in the context of abscess. Patients with intra-abdominal infection may present with rapid-onset abdominal pain, anorexia, nausea, emesis, and obstipation, with or without signs of inflammation, such as fever, tachycardia, tachypnea, or tenderness. CT imaging with helical scanning is preferred to ultrasound when assessing for intra-abdominal infection. Clinical factors that predict failure in source control for intra-abdominal infections include delay in initial intervention past 24 hours, high illness severity, advanced age, comorbidity and degree of organ dysfunction, hypoalbuminemia, low nutritional status, diffuse peritonitis, malignancy, and inability to achieve adequate debridement or drainage. The preceding surgical procedure should be taken into consideration, but generally, the principles of treatment include (1) empiric antibiotic treatment, depending on the location of the collection and most likely source; (2) culture from the organ space or abscess to narrow antimicrobial treatment spectrum; and (3) source control, or eliminating the infectious source, to decrease duration of treatment and risk of persistence. Examples of obtaining source control include opening and debriding a wound to healthy tissue margins, draining abscesses, and removing infected tissue or foreign bodies.

Regarding empiric antibiotic treatment, Infectious Disease Society of America intra-abdominal guidelines provide an excellent resource for the initial approach of a postoperative patient with a suspected intra-abdominal problem. Most gynecologic surgeries will involve polymicrobial infections with microorganisms from the vaginal vault, so this should be considered when selecting a broad-spectrum antibiotic. If an intra-abdominal abscess is confirmed by CT imaging or otherwise, percutaneous drainage is preferable to surgical drainage whenever feasible. However, surgical drainage (via laparotomy or laparoscopy) may be required if the collection is

multifocal, loculated, complex, necrotic, or not accessible to percutaneous drainage. Hemodynamically stable patients with peritonitis (rebound or involuntary guarding on physical examination) may be initiated on empiric antibiotics and monitored closely for up to 24 hours prior to drainage. Patients with a suspected interrupted viscus or fascial dehiscence are typically best treated surgically. Occasionally, if adequate elimination of the infectious source cannot be initially obtained, consideration is given to a planned repeat exploration or deferral on skin and/or fascial closure.

Recommended empiric antibiotic therapy for health care–associated intra-abdominal infection should include coverage against Gram-negative aerobic and anaerobic bacteria and should be guided by local antimicrobial susceptibility data, as more resistant flora may be present. Such organisms may include nonfermenting Gram-negative (*Pseudomonas aeruginosa* and *Acinetobacter* species) and extended spectrum β-lactamase–producing organisms (*Klebsiella* and *E coli*). Possible agents may include (1) carbapenem, (2) piperacillin-tazobactam, (3) ceftazidime plus metronidazole, or (4) cefepime plus metronidazole. Duration of antimicrobial therapy is typically 4-7 days, although more prolonged therapy may be indicated if source control is difficult to achieve. Occasionally, a much longer treatment duration is necessary, as with intra-abdominal infection caused by *Actinomyces* species.

It should be noted that the significance of a fluid collection at the surgical site in the immediate postoperative period may be difficult to assess. Some transudate may normally be present in the pelvis following gynecologic surgery. Posthysterectomy pelvic fluid collections are common shortly postoperatively and appear to resolve within the first 4-5 weeks following surgery. In a small case series, Hasson et al. found that these collections were not related to febrile morbidity.

Application of hemostatic agents such as oxidized regenerated cellulose may also mimic the appearance of an abscess on postoperative imaging. The exact mechanism of action is not fully understood, but it is thought that oxidized cellulose forms a gelatinous collection when mixed with blood that allows for improved platelet aggregation and surgical hemostasis. Oxidized regenerated

cellulose is typically absorbed within 14 days but could take up to 4-8 weeks. As this collection degrades, it can trap air thus appearing as an air-fluid level, which is typically more characteristic of abscesses. Unique imaging features may include a unifocal collection of gas with linear or punctate pattern without an air-fluid level. While magnetic resonance and ultrasound have been suggested as alternative diagnostic modalities to distinguish hemostatic agent from abscess, other clinical features of the patient should be taken into consideration as well as close review of the operative note. Communication of use of hemostatic agent at the time of surgery to the radiology department is important.

# Necrotizing Infections

As previously noted, wound infections caused by *S pyogenes* or *Clostridium* species may present in the first 48 hours after surgery. Additional more serious infections that may present within the first 48 hours postoperatively may include streptococcal toxic shock, myonecrosis, and necrotizing skin infections. In these cases, earlier aggressive surgical management is warranted, in addition to opening the incision, evacuating or debriding necrotic or infected tissue with border demarcation, and initiating antibiotics following collection of wound cultures. After empiric antibiotic initiation, further decision-making for antimicrobial treatment can be further guided by results of the wound culture collection. Patients with rapidly progressing infections warrant close follow-up and evaluation for surgical management. Necrotizing infections are typically polymicrobial but can also be monomicrobial and caused by the following organisms: group A *Streptococcus*, *Aeromonas*, methicillin-resistant *S aureus*, and *Vibrio vulnificus*.

These are progressive infections that may begin as an innocuous-appearing skin lesion that then leads to systemic toxicity. Predisposing factors include diabetes, arteriosclerotic vascular disease, edema/venous stasis, ulcers, and intravenous drug use. Necrotizing infections are associated with a high mortality rate, 30%-70%. Severe pain disproportionate to the appearance of the wound may be the only presenting sign. Any patient with suspicion of

necrotizing fasciitis should undergo prompt surgical consultation and be started on broad empiric antibiotic treatment; penicillin and clindamycin is the preferred regimen for *group A streptococcal* necrotizing fasciitis. More typically, necrotizing fasciitis results from a polymicrobial (mixed aerobic-anaerobic) infection. Potential broad-spectrum antibiotic regimens for necrotizing infections are described in **BOX 12.2**.

### BOX 12.2 SUGGESTED EMPIRIC BROAD-SPECTRUM ANTIBIOTIC REGIMENS FOR NECROTIZING PELVIC INFECTIONS

- Vancomycin plus piperacillin-tazobactam
- Vancomycin plus carbapenem
- Vancomycin plus ceftriaxone and metronidazole
- Linezolid plus piperacillin-tazobactam
- Linezolid plus carbapenem
- Linezolid plus ceftriaxone and metronidazole

Another rare cause of early fever and systemic illness is staphylococcal wound toxic shock syndrome, in which case the wound may appear disproportionately benign to the overall clinical presentation. Early findings may include fever, hypotension, abnormal hepatic and renal function tests, diarrhea, and wound erythroderma. Desquamation may be a later finding. Appropriate management similarly involves wound incision, drainage, culture collection, and initiation of antistaphylococcal treatment.

## Vaginal Cuff Infection

Vaginal cuff cellulitis is thought to account for 2.5%-6.25% of SSIs following hysterectomy. In a large retrospective review and systemic analysis, rates of vaginal cuff infection did not significantly vary by laparoscopic vs robotic (OR 1.34, 95% CI 0.46-3.86, *P* = .59),

vaginal vs laparoscopic (OR 0.42, 95% CI 0.15-1.22, *P* = .10), and vaginal vs robotic (OR 0.57, 95% CI 0.14-2.26) approaches.

Presentation of vaginal cuff cellulitis is likely to entail vaginal discharge and pelvic pain, with or without fever. Evaluation for possible vaginal cuff involvement should begin with a thorough physical examination, including a sterile speculum examination and rectovaginal bimanual palpation. Both the speculum and bimanual examinations may assist in visualizing purulent, serous, or feculent discharge, which may point the examiner toward cuff infection, seroma, or fistulous connection to the bowel. It is important to distinguish cuff cellulitis from cuff abscess. Imaging may additionally be helpful in this scenario, by either vaginal ultrasonography or CT scan.

Wet mount saline microscopy and vaginal swab collection for Gram stain and culture should be considered. Bacterial vaginosis may be easily diagnosed by saline microscopy using Amsel criteria. Vaginal culture collection prior to initiation of antibiotics is important. Although culture results will inevitably include coincident vaginal flora and polymicrobial infections are typically anticipated in this setting, identifying a particularly virulent organism, such as *group A Streptococcus* or *Clostridium* species, will be highly valuable to guide clinical decision-making.

If further imaging is obtained and there is evidence of a fluid collection or abscess within the pelvis (and no evidence of spontaneous drainage), drainage via the vaginal cuff should be considered. The patient may be taken to the operating room for an incision and drainage of the vaginal cuff, which may be preferable to percutaneous drain placement in the interventional radiology suite. After the cuff is opened (which may be accomplished via the prior cuff closure in most cases) and fluid collections removed, a drain should be placed. A Malecot drain may stay in place more effectively than a simple drain (such as a Jackson-Pratt) but may need to be sutured in place at the vaginal cuff. Alternatively, a Foley catheter can be used for this purpose. The drain should be kept in place until minimal drainage is obtained. Repeat imaging, such as with ultrasound, may be considered to ensure complete fluid collection removal prior to drain discontinuation.

# TREATMENT OF VULVAR INFECTIONS

Diagnosis and management of vulvar infections encompasses similar microbiologic principles as above. Vulvar infections can be uniquely challenging due to subcutaneous fascial and fatty tissue anatomy that can allow for rapid infectious spread. Tracking is possible from superficial fascial of the mons and labia majora to the fascia of the inner thigh and anterior abdominal wall. Internal to this layer is a deeper fascial layer that is continuous with Scarpa fascia of the anterior abdominal wall. A solid working knowledge of other anatomical features of interest can help localize a potential infection, such as location of openings of Bartholin and Skene glands around the introitus.

Cellulitis typically involves more superficial layers. Documented risk factors for vulvar cellulitis not only overlap with known risk factors for SSI but also include pregnancy, trauma, vulvar hygiene measures (shaving/waxing), as well as iatrogenic trauma from surgery or childbirth.

Differential diagnosis includes Bartholin or Skene gland abscess, cellulitis, vulvar Crohn disease, hidradenitis suppurativa, and necrotizing infection. It is important to have a high index of suspicion for necrotizing infections, which can spread quickly and present with delayed signs of infection (dusky appearance of skin, crepitance, superficial thrombosis).

Vulvar abscesses are most commonly polymicrobial, but due to a high prevalence of MRSA, antimicrobial treatment should encompass coverage of this organism. Outpatient therapy may be appropriate for a mild purulent cellulitis without risk factors; otherwise, consideration should be given for intravenous antibiotic administration. Inpatient management for patients with concomitant diabetes mellitus should be considered. Surgical incision and drainage while assessing tissue viability should also be considered.

Trimethoprim-sulfamethoxazole may be adequate antibiotic treatment for vulvar abscess; dicloxacillin or cephalexin may be substituted if methicillin-sensitive *S aureus* is present. Severe vulvar

infections should be treated with intravenous vancomycin, daptomycin, or linezolid if MRSA is involved or with nafcillin or cefazolin if methicillin-sensitive *S aureus* is present. Nonpurulent cellulitis without an obvious abscess can be treated with an oral penicillin or cephalosporin. If symptoms do not resolve or if moderate to severe cellulitis with signs of systemic illness is present, consideration is again given to intravenous antibiotic therapy and possible surgical debridement. Intravenous antibiotic choice will typically include a broad-spectrum β-lactam antibiotic with additional coverage for MRSA or anaerobic species.

## ANTIBIOTIC HYPERSENSITIVITY

Penicillin allergy is reported in up to 15% of inpatients, but more than 95% of patients evaluated for penicillin allergy are found to not have true penicillin and cephalosporin allergies. Overreporting of penicillin allergy leads to overuse of alternative antibiotics (such as vancomycin, clindamycin, aminoglycosides, and aztreonam), which may be less clinically effective than β-lactam class and more expensive and have increased side effects. Additionally, patients with reported penicillin allergy have increased odds of harboring MRSA or vancomycin-resistant *Enterococcus*. Blumenthal et al. compared standard allergy skin testing and a computerized guideline to routine care. In this study, skin testing resulted in a significant increase in the safe use of penicillin and cephalosporins. This option should be considered for patients reporting penicillin allergy.

## KEY POINTS

- Surgical site infections are the most common surgical complication and result in increased cost, duration of hospital admissions, and risk of patient morbidity and mortality.
- Prevention is key to SSI control and requires a collaborative effort between clinicians, nurses, and staff.

- In gynecologic surgery, most SSIs are polymicrobial, originating from the patient's skin or vaginal bacterial flora.
- Assessment of the febrile postoperative patient should include evaluation of the surgical wound, as well as the urinary, respiratory, and GI tracts.
- Onset of SSI within 48 hours of surgery or rapid spread should prompt an aggressive workup to rule out necrotizing infection.
- Postsurgical pelvic or vaginal cuff abscesses must be drained and cultured to increase the effectiveness of antibiotic treatment.
- Most patients reporting penicillin allergy do not report an immediate hypersensitivity reaction or exfoliative dermatitis that may otherwise preclude use of penicillin or a cephalosporin. Care should be taken to clarify the type of reaction and consider conducting allergy testing. Patients administered non–β-lactam antibiotic prophylaxis have a higher risk for SSI.

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# CHAPTER 13

# CRITICAL CARE OF THE GYNECOLOGIC PATIENT

Duncan J. McLean and William M. Hart

**Shock**
Management of Shock
Hemodynamic Monitoring
Acid-Base Review
Use of Vasopressors and Inotropes
**Intravenous Volume Resuscitation**
Fluid Status
Fluid Choice
Workup of Oliguria
Electrolyte Replacement
**Acute Respiratory Distress Syndrome**
Pathophysiology
Management
**Patient Case Studies**
Patient 1 With Sepsis and ARDS
Patient 2 With Postoperative Hemorrhage

Critical care is the care of patients with life-threatening pathology. On a practical level, this can be defined as patients who need support of two or more organ systems or just the pulmonary system. Furthermore, patients whose nursing and monitoring needs are more frequent than can be provided in other inpatient environments can be cared for in an intensive care unit.

Critical care medicine involves understanding how organ systems dysfunction in severe illness and how to best support the patient through acute disruptions in their physiology. While this topic is vast, we will cover the pertinent points as they can be applied to the care of the gynecologic patient.

# SHOCK

Shock is defined as a state of circulatory inadequacy resulting in organ hypoperfusion. In turn, this can lead to ineffective oxygen utilization and a derangement of normal metabolic processes. The oxidative stress and cellular injury arising from anaerobic metabolism can contribute to systemic inflammatory response syndromes and ultimately to multiorgan dysfunction. Shock can develop from a variety of pathophysiologic triggers, and it is important to identify the true source to appropriately correct the etiology and its sequelae.

There are four primary categories of shock: hypovolemic, distributive, cardiogenic, and obstructive. Hypovolemic shock is characterized by a loss of intravascular volume that may be secondary to hemorrhage (plasma loss), fluid loss without appropriate resuscitation (vomiting, diarrhea, insensible loss), or dramatic fluid shifts (due to intestinal obstruction, cirrhosis, thermal injury). Consequences of the loss of intravascular volume include a decrease in preload and venous return resulting in a decrease in stroke volume and cardiac output (CO). The subsequent compensatory mechanism is an increase in systemic vascular resistance (SVR) and heart rate. In addition to hypotension and tachycardia, other common physical findings include dry mucous membranes, low jugular venous distension, and decreased skin turgor (**TABLE 13.1**).

## TABLE 13.1
## Classification of Shock

| TYPES OF SHOCK | ETIOLOGY |
|---|---|
| Hypovolemic | Hemorrhage, dehydration, vomiting, diarrhea, fluid shifts |
| Distributive | Sepsis, anaphylaxis, adrenal insufficiency |
| Cardiogenic | Myocardial infarction, valvular dysfunction, pulmonary hypertension |
| Obstructive | Pulmonary embolism, tension pneumothorax, cardiac tamponade |

Conversely, distributive shock is typified by a profound decrease in systemic vascular resistance (SVR) due to a systemic vasodilation from an abnormal distribution of microvascular blood flow. Common causes of distributive shock include sepsis, anaphylaxis, adrenal insufficiency, or a neurogenic etiology. The significant decrease in SVR may be accompanied by a noteworthy normal or slightly increased CO. Due to the vasodilation and increased CO, a patient's extremities will often be warm in contrast to the cold clammy findings associated with hypovolemia.

Cardiogenic shock is a state of hypoperfusion secondary to cardiac failure. The most common cause of cardiogenic shock is acute ST-elevation myocardial infarction or non–ST-elevation myocardial infarction, but other etiologies may include left or right ventricular heart failure, valvular dysfunction, rupture of cardiac structure, or pulmonary hypertension. It is characterized by hypotension with a significant decrease in CO or cardiac index. Common physical findings include a faint rapid pulse, cold extremities, peripheral edema, and jugular venous distension.

The fourth type of shock, obstructive, is sometimes referred to as a type of cardiogenic shock. This occurs secondary to a physical obstruction of the flow of blood with a subsequent significant

decrease in CO. The obstruction may be in one of the great vessels or within the heart itself and can include a pulmonary embolism, thrombus, cardiac tamponade, or tension pneumothorax. This leads to a decrease in preload as well as a profound increase in afterload. Coupled with the decrease in CO, this type of shock is notable for findings of tachycardia, tachypnea, jugular venous distension, and cool extremities.

## Management of Shock

The primary goal in the management of shock is to address the underlying etiology. In the interim, it is imperative to restore perfusion to the organs to aid with oxygen delivery and avoid end-organ damage. An approach proposed by Weil and Shubin in 1969 is still relevant and can help guide the early steps in management of the patient with shock. They put forth the VIP PS methodology that focused on **V** entilation, **I** nfusion, **P** umping and then added **P** harmacological support and **S** urgical management. With **V** entilation, the focus is on the proper supply of oxygen and removal of carbon dioxide whether that be with supplemented spontaneous breathing or mechanical ventilation. **I** nfusion serves as a reminder to adequately replace intravascular volume as needed, and **P** umping guides the provider in supporting cardiac function to ensure adequate output. The pathway then flows to specific pharmacological support to aid perfusion and treat underlying disorders and surgical management of the primary etiology (**BOX 13.1**).

### BOX 13.1 STRATEGY FOR MANAGEMENT OF SHOCK

Ventilation

Infusion

Pumping

Pharmacological support

Surgical management

This approach helps to organize a general management strategy of shock, but it is important to tailor the regimen to the specific type of disorder. Principles may be similar across the various forms of shock, but each type does have some specific special considerations.

As hypovolemic shock is marked by a loss of intravascular volume, the main goal of treatment is fluid replacement. Depending on the source of the loss, this may be accomplished with crystalloid or colloid fluids or various forms of blood products. The magnitude and duration of decreased organ perfusion is directly related to mortality, so immediate initiation of fluid replacement is essential. Accordingly, a consideration needs to be made for the adequacy of intravascular access utilizing multiple large-bore peripheral intravenous lines or a central venous catheter. While the intravascular volume is being replaced, the use of vasoactive medications may be necessary to help support the blood pressure.

With distributive shock, there is an emphasis on early initiation of goal-directed fluid resuscitation as well as treatment of the underlying etiology. For sepsis, starting fluid resuscitation within the first 6 hours has been shown to improve the 28-day survival. The Surviving Sepsis Campaign recommends the rapid administration of 30 mL/kg of crystalloid for hypotension or elevated lactate above 4 mmol/L. Additional goals of fluid resuscitation include maintenance of a mean arterial pressure (MAP) > 65 mm Hg, a urine output >0.5 mL/kg/h, and normalization of lactate level. Empiric broad-spectrum antibiotics should be started within the first hour of treatment after blood cultures have been obtained. For an anaphylactic etiology, in addition to fluid resuscitation, epinephrine should be administered immediately. Supplemental oxygen with possible endotracheal intubation may be necessary in addition to treatment of bronchospasm with inhaled β-adrenergic agents. Glucocorticoids (methylprednisolone 125 mg IV or hydrocortisone 500 mg IV) are

typically administered along with an H2 antagonist for long-term control. Distributive shock with a neurogenic origin will often require atropine or epinephrine to treat symptomatic bradycardia in addition to fluid administration.

Cardiogenic and obstructive shock management differs in that it requires a prudent utilization of fluids. Since the hallmark of this type of shock is pump failure and edema, fluid accumulation is a concern and addition of fluid can complicate the course. Instead, the emphasis is placed on supporting cardiac function with the utilization of vasoactive medications including inotropes or vasopressors (discussed later in this chapter). In severe cases, invasive support including extracorporeal membrane oxygenation may be necessary. Pharmacological or surgical reperfusion in the form of revascularization or thrombolysis can be initiated as indicated as well as invasive treatment of tamponade or pneumothorax.

# Hemodynamic Monitoring

The objective of hemodynamic assessment is to estimate organ perfusion as closely as possible. In the absence of technology that measures flow at individual organ vascular beds, we must utilize more readily available data to estimate organ perfusion. The most common surrogate is measurement of blood pressure. Up to one-third of all intensive care–level patients will experience circulatory shock, so an understanding of how to utilize various monitoring methods is necessary.

The first step in monitoring is thorough clinical examination. Some studies suggest that the prognostic value of a simple model evaluating systolic blood pressure, temperature, level of consciousness, and urine output can match that of the validated Simplified Acute Physiology Score (SAPS-II) and Acute Physiology and Chronic Health Evaluation (APACHE-IV) calculations. These scales take physical examination findings and add them to laboratory assessments to provide guidance on severity of disease classification.

The next step in patient assessment is hemodynamic monitoring, which collects objective data concerning the patient’s condition.

Placement of an arterial catheter allows for the continuous blood pressure measurement and monitoring. Although noninvasive blood pressure monitoring can be utilized, an arterial line provides more accurate information and provides beat-to-beat variations in blood pressure and can more quickly identify significant changes in patient condition. Additionally, an arterial catheter allows easy sampling for blood gases that include lactate levels, hemoglobin, and information regarding acid-base status. A central venous catheter allows assessment of the central venous pressure and central venous oxygen saturation ($S_{CV}O_2$). The central venous pressure correlates with venous pressure, and right ventricular filling pressure, but is not reliable in isolation to define a patient's fluid status. $S_{CV}O_2$ provides information on the effectiveness of oxygen delivery and determines its consumption. A central venous catheter can be used to deliver vasoactive medications, fluids, or blood products (**TABLES 13.2 and 13.3**).

## TABLE 13.2
## Basic Hemodynamic Monitoring

| METHOD | DIAGNOSTIC VARIABLES | DEFINITION | CRITERION | DIAGNOSTIC VALUE | PROGNOSTIC VALUE |
|---|---|---|---|---|---|
| Clinical examination | $\Delta T_{c-p}$ | The difference between central temperature measured by a bladder thermistor catheter and peripheral temperature measured by a skin probe on the big toe of the foot | Pathological if more than 7 °C | Patients with a higher $\Delta T_{c-p}$ have a lower cardiac index | Mean 24-h $\Delta T_{c-p}$ is correlated to mortality |
| | Subjective temperature | Subjective temperature measured as "cool" or "warm" on the extremities | Cool extremities if all examined extremities were cool, or only the lower extremities were cool despite warm upper extremities | Patients with cool extremities have a lower cardiac index than patients with warm extremities | ICU nonsurvivors more often had cold extremities |
| | Capillary refill time | Measured by applying pressure to the ventral surface of the right index finger distal phalanx with a glass microscope slide. Increased pressure until the skin is blank and then maintained for 10 s | Refill time >3 s is defined as abnormal | Low correlation with CO<br>Not different between patients with and without shock | Strong predictive factor of mortality and in-hospital mortality |
| | Skin mottling | Patchy skin discoloration that usually starts around the knees because of heterogenic small vessel vasoconstriction | Score 0 indicates no mottling<br>Score 1, a small mottling area (coin size) localized to the center of the knee<br>Score 2, a mottling area that does not exceed the superior edge of the kneecap<br>Score 3, a mottling area that does not exceed the middle thigh<br>Score 4, a mottling area that does not go beyond the fold of the groin<br>Score 5, an extremely severe mottling area that goes beyond the fold of the groin | Incidence of 49% in patients with septic shock<br>Low diagnostic accuracy for CO | A predictive factor of mortality in critically ill patients and patients with shock |
| Arterial catheter | Blood pressure monitoring | Continuous monitoring of the pressure of the blood in the circulatory system while maintaining a reliable arterial blood pressure waveform | Guidelines recommend an initial MAP above 65 mm Hg in all shock states except for hemorrhagic shock, to be individualized based on clinical evaluation | Circulatory shock does not require the presence of hypotension | MAP is independently associated with mortality in shock |
| Blood gas analysis | Lactate | Product of glucose and pyruvate metabolism. In shock states, blood lactate levels increase because of many potential causes. Measured in a reliable way | Increased if >1.5 mmol/L | The definition of shock is insufficient oxygen delivery to the cells, which leads to hyperlactatemia<br>Cannot be used to differentiate between patients with and without shock | Higher lactate levels were associated with increased mortality<br>Better patient outcome is observed with decreasing lactate levels |

| | | | | | |
|---|---|---|---|---|---|
| | $P_{v-a}CO_2$ or $CO_2$ gap | Marker of the adequacy of blood flow to remove $CO_2$ from the tissues | Normal if <6 mm Hg and increased if >6 mm Hg | Patients with septic shock with increased $P_{v-a}CO_2$ (>6 mm Hg) had a lower CO than those with normal $P_{v-a}CO_2$ | Normalization of $P_{v-a}CO_2$ is associated with a decrease in blood lactate |
| Central venous catheter | CVP | Pressure measured in the superior vena cava, used as a surrogate for right atrial pressure | Normal between 0 and 5 mm Hg | CVP is useful in diagnosing the type of shock<br>However, unless in the extreme ranges of the variables (such as a CVP of 0 mm Hg with bleeding), CVP should always be interpreted together with other variables | Nonsurvivors of shock have a higher CVP at ICU admission and after 24-48 h |
| | $S_{CV}O_2$ | Oxygen saturation measured in the superior vena cava used as a surrogate for mixed venous oxygen saturation | Low if <70%, high if >80% | Low $S_{CV}O_2$ indicates an inadequacy of oxygen transport or high oxygen consumption, especially in the context of hyperlactatemia<br>Normal or high $S_{CV}O_2$ cannot discriminate if oxygen transport is adequate | Persistence of low $S_{CV}O_2$ is associated with higher mortality |

$\Delta T_{c-p}$, central-to-peripheral temperature difference; CO, cardiac output; CVP, central venous pressure; MAP, mean arterial pressure; $P_{v-a}CO_2$, difference of partial pressures of $CO_2$ in venous and arterial blood gas; $S_{CV}O_2$, central venous oxygen saturation.

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# TABLE 13.3
# Advanced Hemodynamic Monitoring

| METHOD | INDICATION | DIAGNOSTIC VARIABLES | VARIABLE TO GUIDE TREATMENT | CAUTION | CO VALIDATION |
|---|---|---|---|---|---|
| Critical care echocardiography | Indicated as the first measurement of CO in patients suspected of circulatory shock | Left and right heart function<br>Tamponade<br>Cardiac contusion<br>Hemothorax<br>Outflow obstruction<br>Pulmonary edema | CO<br>Fluid responsiveness variables<br>Titration of vasoactive medication by measuring ventricular function | Not considered a monitoring device as continuous measurements are not possible<br>Acoustic windows may not be obtainable in up to 30% of patients | Not interchangeable compared with thermodilution, using data from 799 patients in 24 studies<br>Interchangeable compared with thermodilution, using data from 1996 patients in 68 studies |
| Pulse contour analysis | Indicated in patients, which require continuous CO measurements to assess fluid responsiveness | $dP/dt_{max}$ was proposed as an estimator of left ventricular function; however, recent evidence suggests $dP/dt_{max}$ may be unreliable for this purpose | CO<br>Fluid responsiveness variables<br>$Ea_{dyn}$ may potentially be used to reduce vasopressor doses in patients with sepsis | Interpret CO values with caution in patients with arrhythmias or hyperdynamic conditions, such as liver failure or circulatory shock | Adequate measurement performance in normal and hypodynamic conditions, but not during hyperdynamic conditions, using data from 2234 patients in 65 studies |
| Esophageal Doppler | Indicated in patients who require continuous cardiac output measurements | None | CO<br>FTc | Limited to patients under sedation or general anesthesia because of the requirement to insert an esophageal probe | Accurate measurement performance compared with PAC, using data from 314 patients in 11 studies |
| Transpulmonary thermodilution | Indicated in patients who have circulatory shock associated with ARDS | PVPI and EVLW differentiate pulmonary edema from ARDS<br>CFI is a reliable estimator of left ventricular systolic function | CO<br>Elevated PVPI and EVLW are associated with increased mortality in patients with ARDS | Requires cannulation of the femoral artery and central venous access, which can be associated with complications<br>Obtaining CO values can be limited by factors related to the indicator (eg, loss of indicator, temperature differences), patient-specific factors (eg, intracardiac shunts, tricuspid regurgitation, low-flow states) | Accurate measurement performance compared with PAC, using data from 239 patients in 10 studies |
| Pulmonary artery catheter | Indicated in patients who have circulatory shock associated with right ventricular dysfunction or pulmonary arterial hypertension | Used to diagnose right ventricular dysfunction and pulmonary arterial hypertension<br>PCWP can be used for the diagnosis of cardiogenic shock | CO<br>PAP<br>PCWP<br>RAP | Considered as invasive procedure associated with rare but severe complications<br>Obtaining CO values can be limited by factors related to the indicator (eg, loss of indicator, temperature differences), or patient-specific factors (eg, intracardiac shunts, tricuspid regurgitation, low-flow states) | The clinical gold standard method for CO measurement<br>Relatively accurate compared with experimental reference standards (eg, flow probe) |

ARDS, acute respiratory distress syndrome; CFI, cardiac function index; CO, cardiac output; $dP/dt_{max}$, maximum rate of the arterial pressure increase during systole; $Ea_{dyn}$, dynamic arterial elastance; EVLW, extravascular lung water; FTc, corrected flow time; PAC, pulmonary artery catheter; PAP, pulmonary arterial

pressure; PCWP, pulmonary capillary wedge pressure; PVPI, pulmonary vascular permeability index; SV, stroke volume; SVR, systemic vascular resistance; RAP, right atrial pressure.
Reprinted with permission from Kaufmann T, van der Horst ICC, Scheeren TWL. This is your toolkit in hemodynamic monitoring. *Curr Opin Criti Care*. 2020;26(3):303-312, Table 2.

Advanced hemodynamic monitoring employs more sophisticated methods for obtaining information concerning CO or other hemodynamic parameters. Transthoracic or transesophageal echocardiography provides a visual evaluation of cardiac function including estimates of ejection fraction, valvular dynamics, wall motion abnormalities, and fluid responsiveness. Limitations of this modality include dependence on operator skill and the inability to use it as a continuous monitor. Pulse contour analysis utilizes information from an arterial line waveform to provide estimates on CO and fluid responsiveness. Transpulmonary thermodilution takes advantage information from a central venous catheter and arterial catheter to measure a change in blood temperature after injection of cold saline as a determinate of CO. The esophageal Doppler monitor uses the velocity of esophageal blood flow as a surrogate for CO but can only be utilized in patients who are sedated or under general anesthesia. Finally, the most invasive advanced monitor is the pulmonary artery catheter. This device is placed via a central venous catheter into the pulmonary artery and reports the patient's right atrial pressure, right ventricular pressure, filling pressures, and uses thermodilution to assess CO. This information from a pulmonary artery catheter will diagnose pulmonary hypertension and right heart failure and provide information regarding responsiveness to medications.

# Acid-Base Review

In the critically ill patient, acid-base disturbances are common and proper interpretation of the nature of the abnormality will guide diagnosis and management. Multiple methods have been proposed to evaluate acid-base disturbances including the physiological approach, base excess approach, and the physiochemical (or Stewart) approach as well as use of the Henderson-Hasselbalch

equation. No one method has proven superior, but what is recommended is a systematic stepwise assessment to allow for appropriate evaluation of the patient. The method described in this chapter mimics the standard physiological approach, which is based on the carbonic acid-bicarbonate buffer system. Whenever a change occurs in the partial pressure of $PCO_2$, a secondary adaptive response occurs in the bicarbonate concentration and vice versa.

Like with hemodynamic monitoring, the first step is to perform a history and physical examination. Taking into consideration the patient's vital signs, neurological status, and recent history, an overall understanding of what may be contributing to the acid-base disturbance can be determined. Underlying medical conditions and organ dysfunction, signs of infection, gastrointestinal symptoms, or recent medication or substance use may suggest the origin of a particular acid-base abnormality.

The second step is to determine what is the primary disorder and then the subsequent secondary adaptive response. Based on the primary abnormality and the pH level, acid-base disturbances can be categorized as one of four types: respiratory acidosis, respiratory alkalosis, metabolic acidosis, or metabolic alkalosis. Disorders that are respiratory in nature can further be broken down into acute vs chronic with a predictable pattern in the metabolic response. If the secondary response appears to differ from what is predicted, then a mixed acid-base disorder is present.

If a metabolic process is evident, the third step is an evaluation of the potential source of the derangement. The anion gap (AG) is the difference between measured positively charged cations ($Na^+$ and $K^+$) and measured negatively charged anions ($Cl^-$ and $HCO_3^-$). Calculating the anion gap [$(Na^+) - (Cl^-) - (HCO_3^-)$] will help to determine the etiology of a metabolic acidosis (**BOX 13.2**). A high anion gap can be suggestive of an over production of acid, ingestion of a substance, or an under excretion of acid, whereas a normal anion gap may indicate a significant loss of bicarbonate. While the most common causes of high AG acidosis are lactic acidosis and ketoacidosis, determining the delta AG ratio to delta $HCO_3$ ($\Delta AG/\Delta HCO_3$) will identify other causes of high AG acidosis or whether a

mixed process is ongoing. Conversely, an examination of the urine electrolytes, specifically the chloride, can identify the origin of a metabolic alkalosis (chloride responsive or chloride resistant) (**FIG. 13.1**).

## BOX 13.2 NORMAL AND ELEVATED ANION GAP

### Formula of Serum Anion Gap

Serum anion gap = Na − (Cl + $HCO_3$)

**Causes of high anion gap metabolic acidosis**

Methanol

Uremia

Diabetic ketoacidosis

Paracetamol/acetaminophen

Iron/isoniazid

Lactic acidosis

Ethanol/ethylene glycol

Salicylate/ASA

Carbon monoxide/cyanide

Aminoglycosides

Theophylline

**Causes of normal anion gap metabolic acidosis**

Ureterostomy

Small bowel fistula

Extra chloride

Diarrhea

Carbonic anhydrase inhibitor

Adrenal insufficiency

Rental tubular acidosis

Pancreatic fistula

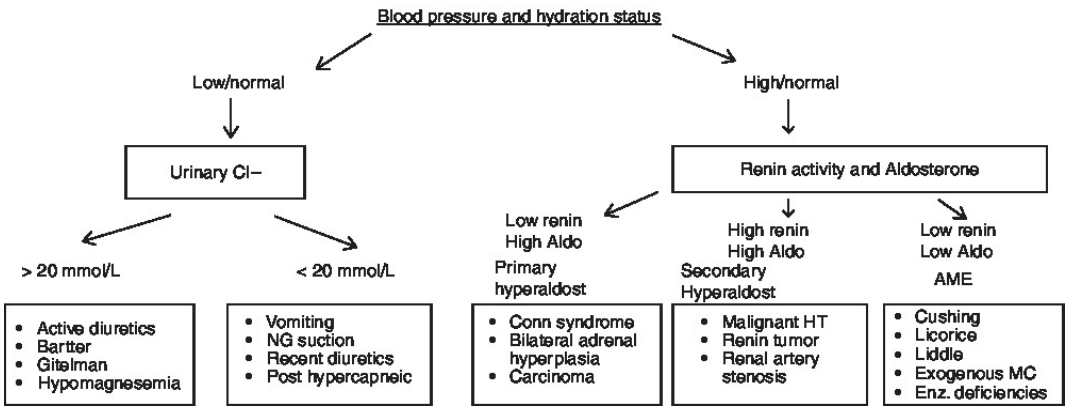


**FIGURE 13.1** Diagnostic workup of metabolic alkalosis. (From Gillioin V, Jadoul M, Devuyst O, et al. The patient with metabolic alkalosis. *Acta Clin Belg*. 2019;74(1):34-40. Reprinted by permission of Taylor & Francis Ltd., http://www.tandfonline.com.)

# Use of Vasopressors and Inotropes

Treatment of circulatory shock will require support in the form of vasopressors or inotropes. To help guide treatment choice, it is useful to consider vasopressors as agents to raise MAP and inotropes to increase CO. Another form of vasoactive medication, the inodilators, are inotropic (impact cardiac contractions) and have vasodilatory effects. An understanding of these three types of medication will aid in their utilization in the various forms of shock (**TABLE 13.4**).

# TABLE 13.4
# Vasoactive Agents

| | MECHANISM | USUAL DOSE RANGE | INOTROPY | CLINICAL USE |
|---|---|---|---|---|
| *Vasoconstrictors* | | | | |
| Phenylephrine | $\alpha_1$ | 0.1-1 μg/kg/min | 0 | Vasoplegia, dynamic LVOT obstruction |
| Vasopressin | $V_{1a}$ | 0.03-0.06 U/min | 0 | Vasoplegia |
| Angiotensin-II | $AT_1$ | 10-40 ng/kg/min | 0 | Refractory distributive shock |
| *Inoconstrictors* | | | | |
| Norepinephrine | $\alpha_1 > \beta_1$ | 0.01-0.3 μg/kg/min | + | First line for distributive shock |
| Epinephrine | $\beta_{1/2} > \alpha_1$ | 0.01-0.3 μg/kg/min | +++ | Cardiogenic and distributive shock |
| Dopamine | $\beta_1 > \alpha_1$ | 2-10 μg/kg/min | +++ | Second-line inotrope or bradycardia (low dose) |
| *Inodilators* | | | | |
| Dobutamine | $\beta_{1/2} > \alpha_1/\beta_2$ | 2-10 μg/kg/min | +++ | First-line inotrope for cardiogenic shock |
| Isoproterenol | $\beta_{1/2}$ | 0.01-0.1 μg/kg/min | +++ | Bradycardia |
| Milrinone | PDE-3I | 0.1-0.5 μg/kg/min | ++ | Alternative inotrope for cardiogenic shock (caution: accumulates in renal failure) |
| Levosimendan | PDE-3I[a] | 0.05-2 μg/kg/min | ++ | Not FDA approved for clinical use in the United States |

[a]Also sensitizes myofilaments to calcium.
FDA, Food and Drug Administration; LVOT, left ventricular outflow tract; PDE-3I, phosphodiesterase-3 inhibitor. α1 alpha 1 adrenergic, V1a vasopressin-1a, AT1 angiotensin 1, β1 beta 1 adrenergic, β2 beta 2 adrenergic
From Jentzer JC, Hollenberg SM. Vasopressor and inotrope therapy in cardiac critical care. *J Intensive Care Med*. 2021;36(8):843-856. Copyright © 2021 SAGE Publications. Reprinted by permission of SAGE Publications, Inc.

Vasopressors exert their effect on various receptors to augment cytosolic calcium availability in vascular myocytes leading to peripheral vasoconstriction. These agents are catecholamine and noncatecholamine based. The catecholamine vasopressors norepinephrine and phenylephrine act on the alpha 1 (α1) adrenergic receptors to increase calcium signaling. Noncatecholamine vasopressors such as vasopressin and angiotensin-II activate vasopressin-1a ($V_{1a}R$) and angiotensin receptor-1 ($AT_1R$) sites with similar downstream effects of increasing calcium utilization. For sepsis and left ventricular–based cardiogenic shock, norepinephrine is considered the first-line agent with vasopressin as a second-line adjunct. Other potential agents are under review, including an angiotensin II analogue.

Inotropic and inodilator medications increase the force of myocardial contraction with the secondary effect of increasing overall stroke volume. Many of these agents will often increase heart rate as well with both effects acting to increase CO. These agents activate beta 1 ($\beta_1$) adrenergic receptors thereby enhancing cytosolic calcium availability in cardiac-specific myocytes. Peripherally, activation of the $\beta_2$ receptors by inodilators additionally leads to vasodilation causing a reduction in afterload. Other inodilators are phosphodiesterase-3 inhibitors and increase cytosolic cyclic AMP levels. One of the more well-known inotropes, epinephrine, is utilized as a second-line vasopressor as well as a first- or second-line inotrope. Dobutamine, an inodilator, is used first line for inotropic treatment of left ventricular cardiogenic shock. Another inodilator, milrinone, can treat cardiogenic shock, although it is extensively renally cleared so must be used cautiously in patients with renal dysfunction.

It is important to keep in mind that, like all medications, vasoactive agents can have significant side effects. They demonstrate a curvilinear dose-response relationship with most of the clinic benefit occurring at lower doses. With an increase in the dose, there is a greater risk for the development of toxicity manifested as tachycardia, tachyarrhythmias, and organ hypoperfusion. Judicious use of these medications in conjunction with an algorithmic approach (**FIG. 13.2**), however, can potentially be lifesaving in critically ill patients with shock.

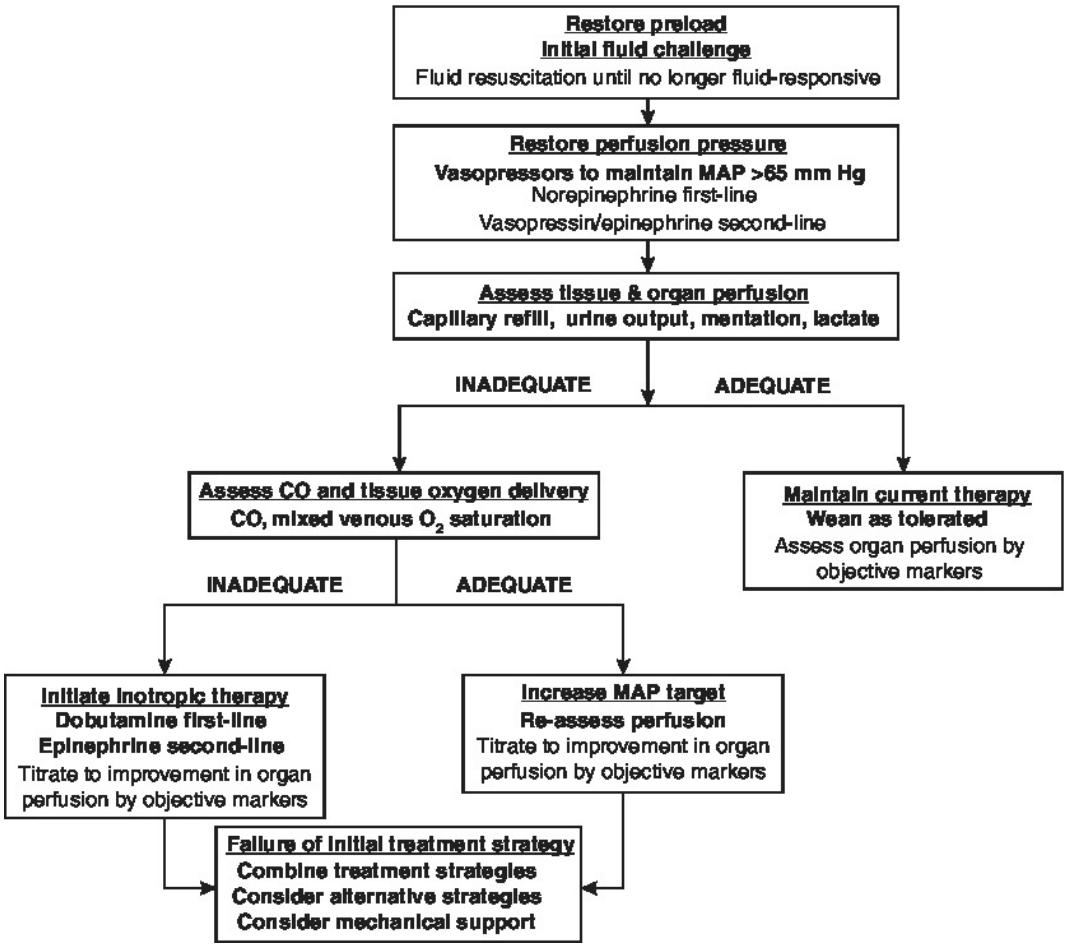


**FIGURE 13.2** Algorithm for use of vasoactive medications. (From Jentzer JC, Steven Hollenberg SM. Vasopressor and inotrope therapy in cardiac critical care. *J Intensive Care Med*. 2021;36(8):843-856. Copyright © 2021 SAGE Publications. Reprinted by permission of SAGE Publications, Inc.)

## INTRAVENOUS VOLUME RESUSCITATION

Since their first description by Lewins in 1832, intravenous (IV) fluids have become one of the most ubiquitous therapeutics in health care. The purpose of IV fluid administration is to either replace intravascular volume lost from bleeding and evaporation or to substitute ongoing fluid requirement in the setting of inadequate oral intake. The goal of IV fluid administration is to achieve a balanced resuscitation that maintains or restores optimal blood flow to all organs.

# Fluid Status

Fluid status is a term used to describe how full a patient's cardiovascular system is. A low fluid status results in reduced return of venous blood to the heart (low preload), which results in a lower CO and impaired organ perfusion. Excessive intravascular volume leads to edema and may worsen CO by shifting the Frank-Starling curve too far to the right, impairing ventricular contractility. Patients with heart failure are particularly susceptible to this effect.

Insufficient *and* excessive doses of intravascular fluid administration are associated with increased risk of 30-day mortality, respiratory complications, renal injury, length of stay, and hospital costs. Clinical signs such as oliguria, tachycardia, and hypotension are late signs that occur once hypovolemia has become severe. It is important to identify a patient's fluid status early in management. No single measure can consistently assess fluid status reliably; however, when combining multiple measures with thorough clinical assessment, fluid status can be estimated accurately. Dynamic measures such as placing the patient in Trendelenburg position or raising their legs while assessing the inferior vena cava with ultrasound, a non-invasive way to measure intravascular volume, are most accurate. In patients who are intubated, mechanically ventilated, and have an arterial line, pulse pressure variation (PPV) can be measured to monitor fluid status. Low PPV (<13) is usually representative of sufficient intravascular volume, whereas high PPV (>13) may represent hypovolemia. PPV can be elevated when the patient's venous return is impaired, for example, by compression of the inferior vena cava by a gravid uterus.

# Fluid Choice

The most frequently appropriate fluids for most patients and most scenarios are balanced crystalloids such as lactated Ringer or Plasmalyte. Colloids such as albumin and hydroxyethyl starch may be considered when patients respond inadequately to several liters of crystalloid therapy. However, colloids do not offer lasting benefit over crystalloids and are associated with increased bleeding due to platelet dysfunction, can cause renal injury, and are absolutely contraindicated if there is concern for traumatic brain injury due to risk of exacerbating cerebral edema.

# Workup of Oliguria

Causes of oliguria can be divided into three types of dysfunctions:

Prerenal (related to decreased blood flow to the kidneys)

Intrinsic renal (disorders of the renal parenchyma)

Postrenal (renal outlet obstruction)

Initial workup of oliguria includes history and examination to establish likely cause. If a prerenal cause is suspected, this can be further evaluated with ultrasound. Point-of-care ultrasound can establish if the patient is hypovolemic or if the patient is experiencing decreased left ventricular ejection. Doppler ultrasound can be used to calculate renal blood flow or the presence of structural abnormalities in the kidneys and/or renal outflow tract.

In addition to ordering a serum renal function panel that includes serum creatinine, urea, sodium, potassium, and chloride, obtaining urine sodium levels allow for the calculation of a fractional excretion of sodium (FeNa). FeNa is calculated as a percentage using the following formula:

$$\text{FeNa} = \frac{(\text{Urine Sodium} \times \text{Serum Creatinine})}{(\text{Serum Sodium} \times \text{Urine Creatinine})} \times 100$$

- A FeNa < 1% is suggestive of a prerenal cause of renal injury.
- A FeNa > 2% is suggestive of intrinsic renal dysfunction such as acute tubular necrosis, leading to impaired sodium reabsorption by the kidneys.
- A FeNa 1-2 is borderline and requires further investigation to establish the cause of renal injury. FeNa can be influenced by multiple factors and as such should be interpreted with caution:
  - Serum creatinine can be influenced by muscle density, diet, and catabolic status.
  - Diuretic use can falsely elevate the FeNa due to increased renal sodium excretion.
  - Acute kidney injury due to contrast-induced nephropathy can result in a FeNa < 1%.

In the surgical patient, the most common cause of oliguria is hypovolemia. Ensuring that your patient begins their surgical journey in a normovolemic state will reduce their intraoperative IV fluid requirements and is associated with improved postoperative outcomes.

# Electrolyte Replacement

Electrolyte imbalances occur commonly in ill patients and in the perioperative period. These occur secondary to a patient's disease process or incidental and secondary to medical management. The most common disordered electrolytes are sodium, potassium, phosphate, and calcium.

## *Sodium*

Sodium balance is typically related to serum free water. Excessive free water dilutes serum sodium, and insufficient free water results in a higher sodium concentration. However, there are conditions that can result in excessive sodium loss (sodium wasting) or less

commonly sodium retention. The syndrome of inappropriate antidiuretic hormone secretion (SIADH) is a phenomenon where an exaggerated amount of antidiuretic hormone (ADH/arginine vasopressin) is secreted by the hypothalamus, resulting in more concentrated urine, increased free-water retention and dilutional hyponatremia. SIADH can be caused by neurologic injury (stroke, traumatic injury, infection), malignancies, and surgery, as well as other less common etiologies. The normal range of sodium is normal range 135-145 mEq/mL.

Typically, sodium abnormalities are addressed by adjusting the amount of free water. If a patient is hyponatremic without excessive sodium wasting, then this can be addressed by restricting their fluid intake. In hypernatremia, free water can be increased by adding free water to tube-feeding formulas if an enteric feeding device is in place, by encouraging oral intake of water, or by administering a hypoosmolar IV fluid such as 5% dextrose.

Caution should be applied when taking care of the patient with severe hyponatremia (<120 mEq/mL), as excessively fast correction can result in permanent and potentially fatal neurologic injury due to osmotic demyelination. The general rule is to correct serum sodium no faster than 6-12 mEq/mL in a 24-hour period. Correction of sodium should ideally be performed with the assistance of a nephrologist and in an environment where high-frequency observation can be achieved such as an ICU.

# *Potassium*

Potassium is a predominantly intracellular ion, and as such, by the time serum concentrations are low, it likely represents a profoundly low intracellular concentration. Both hypo- and hyperkalemia can cause muscle weakness, rhabdomyolysis, and cardiac arrhythmias. The normal range of potassium is 3.6-5.2 mmol/L.

Hypokalemia should be treated with either oral or IV potassium replacement. IV potassium can be a vascular irritant, so replacement should occur slowly and ideally through either a large peripheral vein or through a central venous cannula. Patients should be monitored for cardiac arrhythmias during replacement of potassium.

Hyperkalemia treatment involves several approaches:

1. Assessment of the severity of hyperkalemia. Typically, serum potassium >6.5 mmol/L and/or the presence of clinical symptoms warrant intervention.
2. Stabilization of the cardiac myocardium with IV calcium. Note that this effect typically lasts less than an hour, so repeat dosing is necessary if hyperkalemia persists.
3. Driving serum potassium intracellularly using insulin (with dextrose to prevent hypoglycemia), β-agonism (albuterol and/or low-dose IV epinephrine infusion).
4. Removal of serum potassium by diuresis, dialysis, or one of the new potassium-binding agents such as sodium zirconium (Lokelma) or patiromer (Veltassa).

# *Phosphate*

Phosphate has multiple roles in the body including ossification of bone, formation of cell membranes, and as part of the “energy currency” of cells with oxidative phosphorylation. The normal range of phosphate is 2.8-4.5 mg/dL.

Hypophosphatemia can result in fatigue, weakness, and bone pain. Phosphate can be replaced orally or intravenously. Patients who are chronically malnourished are particularly vulnerable to a condition called refeeding syndrome. This occurs when replacement occurs excessively quickly, causing excessive insulin secretion and intracellular shift of serum phosphate. Phosphate should be frequently checked and replaced in these patients.

Severe, acute hyperphosphatemia can present with symptoms of hypocalcemia, due to binding of calcium. These symptoms include muscle cramps, perioral numbness, and seizures. Treatment of hyperphosphatemia typically involves addressing the underlying cause, binding phosphate in the gut, and the use of loop diuretics.

# *Calcium*

Calcium has many roles in the body including nerve impulse transmission, muscular contraction, vascular tone, and cardiac

contractility. It is metabolically active when in the ionized form, although this only comprises 40% of serum calcium, the rest is bound to proteins and other ions. The normal range of total serum calcium is 8.6-10.3 mg/dL, and ionized calcium is 4.65-5.25 mg/dL.

In the inpatient setting, it is more common to see hypocalcemia than hypercalcemia. This can be due to dilution from IV fluid therapy, binding of calcium to citrate in transfused blood products, acid-base shifts, or renal injury.

Severe hypocalcemia can result in muscle spasm (tetany), seizures, airway irritability, cardiac conduction abnormalities, hypotension, and cardiac arrest.

Correction of hypocalcemia can be enteral or IV, depending on the severity. Patients should be monitored with EKG and blood pressure measurement during rapid corrections to assess for hypertension and cardiac conduction abnormalities.

# *Magnesium*

Magnesium has a wide range of roles in the body including but not limited to facilitating muscle contraction and relaxation, nerve impulse conduction, transport of calcium and potassium, and bone development.

Magnesium administration may be required for a variety of indications including hypomagnesemia, treatment or prophylaxis of preeclampsia and eclampsia, adjunctive analgesia, and treatment of refractory severe asthma. Typical magnesium administration is 1-2 g/h IV, ±4 g IV loading dose, and should occur with continuous monitoring and assessment for side effects of somnolence, hypotension, and muscle weakness.

Hypomagnesemia is far more common than hypermagnesemia, the latter typically only occurring as a result of excessive magnesium administration and/or renal failure. Symptoms of hypermagnesemia include decreased muscle tone, lethargy, hypotension, respiratory failure, and at its worst, cardiovascular collapse. Treatment of hypermagnesemia involves supportive therapy, loop and/or thiazide diuretics, IV fluid administration, and dialysis if necessary.

# ACUTE RESPIRATORY DISTRESS SYNDROME

The acute respiratory distress syndrome (ARDS) is a common manifestation of hypoxic and hypercarbic respiratory failure. ARDS is defined by the Berlin criteria as hypoxia not exclusively attributable to cardiogenic causes sufficient to cause an impaired delivery of oxygen to blood, with radiological findings indicative of diffuse alveolar damage. This usually occurs within 7 days of a known or suspected insult.

The objective measures for each of the Berlin Criteria are listed in **TABLE 13.5**. P/F ratio ($PaO_2/FiO_2$) is a measure of how much oxygen reaches the arterial system and is measured as the partial pressure of arterial blood (P = $PaO_2$) relative to the amount of oxygen delivered to the lungs, measured as a fraction. For example, someone with an arterial partial pressure of oxygen of 85 mm Hg while receiving 100% $FiO_2$ will have a P/F ratio of 85, suggestive of severe ARDS if the other criteria are met.

## TABLE 13.5
## Berlin Criteria for ARDS

| VARIABLE | CRITERIA |
|---|---|
| Hypoxia | P/F ratio 200-300 (mild) |
| | 100-200 (moderate) |
| | <100 (severe) |
| Noncardiogenic | Not fully explained by cardiogenic causes (consider ECHO) |
| Radiologic | Evidence of diffuse, bilateral alveolar damage on CXR or chest CT |
| Temporality | Within 7 d of a suspected insult |

The specification of noncardiogenic cause allows for the presence of cardiogenic pulmonary edema, so long as the pulmonary disease is not fully explained by cardiac disease. Patients will often present with multiple comorbidities, including left ventricular failure that results in cardiogenic pulmonary edema. However, such patients may also suffer from an additional insult that contributes to further pulmonary injury and ARDS.

The classic radiologic finding of ARDS is that of bilateral patchy infiltrates on anteroposterior (AP) chest x-ray. The Berlin criteria allows for chest CT to be used instead of x-ray, but use of lung ultrasound remains controversial. This is likely because ARDS can affect deeper portions of lung tissues, which are less effectively imaged with ultrasound.

# Pathophysiology

ARDS is a syndrome and not a unified disease process. It is the pulmonary manifestation of one or more processes that can be intra- or extrapulmonary. It is thought that the first step in the process is a “priming” of lung tissue that places it in a proinflammatory state, with increased neutrophil presence, then either continuation of the

primary insult or additional insults. Examples of intrapulmonary insults in the gynecologic patient population are aspiration pneumonia or embolism of amniotic fluid. Examples of common additional insults include exposure to transfused blood products, surgical stress, or systemic sepsis.

At the alveolar level, ARDS involves increased permeability of the alveolar membrane and accumulation of inflammatory fluid that impairs gas exchange. If the causative processes are allowed to continue, this can progress to fibroblast proliferation, lung scarring, and irreversible lung injury.

# Management

Many modalities, including stem cell therapy, systemic and inhaled steroids, and biologic agents to target inflammatory pathways, have been trialed to treat ARDS, though no single approach has been found to be broadly applicable. This is likely a reflection of the multifactorial nature of the syndrome. However, the broad principle of management is to minimize the original insults and implement supportive care. Lung-protective ventilation is a term used to describe addressing all modifiable parameters to minimize further injury to the patient from mechanical ventilation.

Mechanical ventilation can cause lung injury in the following ways:

- **Volutrauma**—Trauma resulting from excessive tidal volumes. This is minimized by utilizing tidal volumes of 6-8 mL/kg of ideal body weight. Ideal body weight is calculated from patient height and sex.
- **Barotrauma**—Trauma resulting from excessive pressure across the lung tissue, most notably the alveolar membrane. This is minimized by tailoring ventilator parameters to keep driving pressure no greater than 15 cm $H_2O$. Driving pressure is the difference between positive end-expiratory pressure and plateau pressure, which is the pressure inside the lungs after inspiration is held.

- **Atelectrauma**—Trauma resulting from repeated collapsing and reopening of alveoli. This results in shear forces applied to the alveolar membrane, direct injury, recruitment of inflammatory mediators, and edema. This can be minimized using positive end-expiratory pressure to "recruit" as many alveoli as possible.
- **Hyperoxia**—Trauma resulting from exposure to excessive doses of oxygen. In a dose-dependent fashion, oxygen is injurious to tissue, particularly lung parenchyma. While it is necessary to provide supplemental oxygen to decompensating patients, it is important to reduce the dose of delivered oxygen to the lowest possible level as soon as possible. Ideally, this should be <60% and/or the lowest amount required to achieve an oxygen saturation of 90% or a $PaO_2$ of 60 mm Hg. The only exceptions to these rules are in patients with uncorrected vascular insufficiency to major organs such as severe coronary artery disease, mesenteric ischemia, or critical limb ischemia.

# PATIENT CASE STUDIES

## Patient 1 With Sepsis and ARDS

*A 51-year-old patient with a history significant for poorly controlled type 2 diabetes mellitus, 26 pack-year smoking history, class II obesity (BMI 38), and localized uterine cancer presents to the emergency department on postoperative day 6 after an abdominal hysterectomy*. Vital signs:

- Heart rate 118
- Blood pressure 87/49 (62) after infusion of 2 L of IV lactated Ringer solution
- Respiratory rate 32 breaths/min
- $SpO_2$ 89% on 15 L/min via nonrebreather face mask
- Temperature 103.6 °F (39.8 °C)

An arterial blood gas shows pH 7.29, $pO_2$ 68, $pCO_2$ 49, $HCO_3$ 25 consistent with a metabolic acidosis.

Chest x-ray is shown in **FIGURE 13.3**.

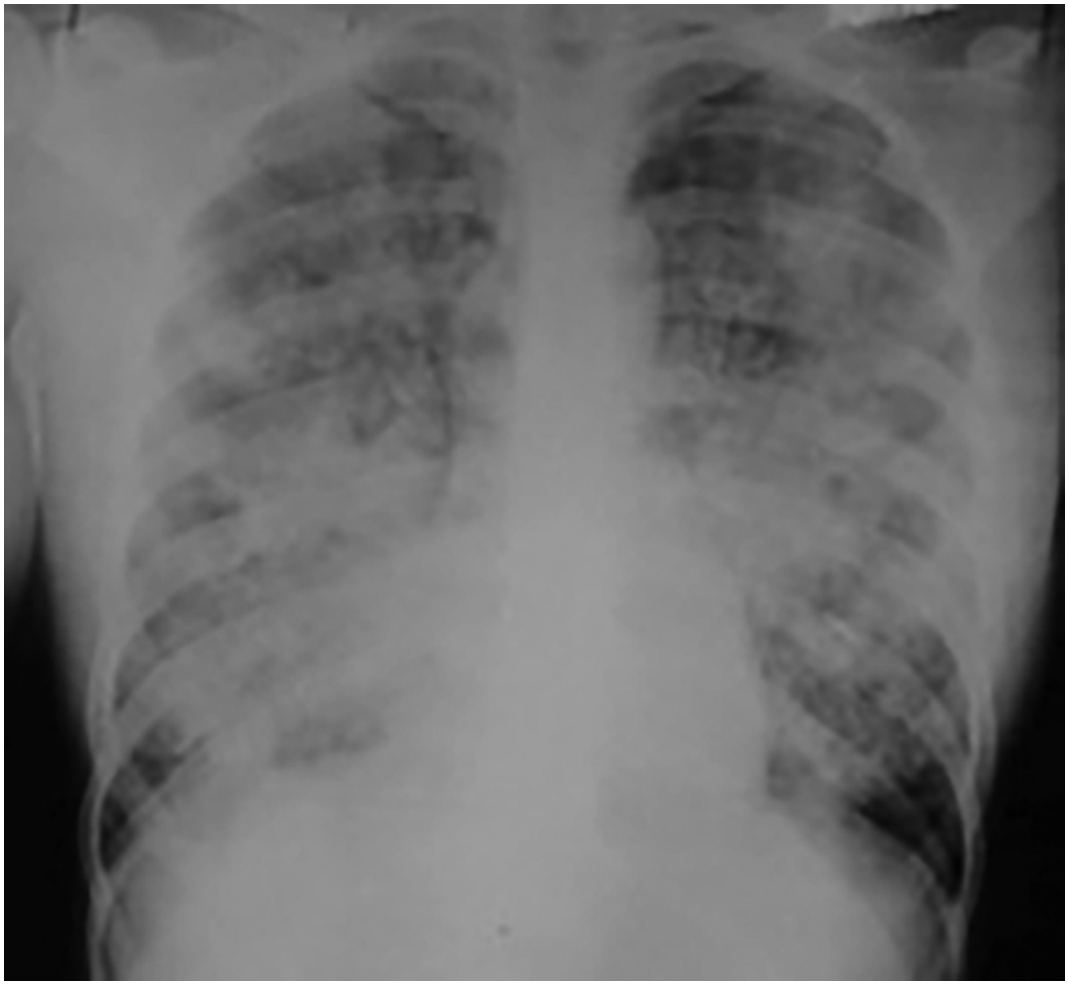

**FIGURE 13.3** Chest x-ray in a patient with sepsis and ARDS.

Examination reveals an obese, unwell-appearing, diaphoretic female with delayed capillary refill in the extremities, labored breathing, bilateral rhonchi, partial breakdown of abdominal incision with tense, erythematous surrounding tissue, and purulent drainage.

The patient has labs drawn and is taken to the intensive care unit. The following steps are addressed urgently:

1. Address hypoxia and labored breathing
   a. Patient likely requires intubation and mechanical ventilation as she remains hypoxic despite supplemental oxygen and is demonstrating signs of tiring.

b. If noninvasive oxygen delivery is chosen, the patient should be monitored constantly for worsening hypoxia, repeat arterial blood gases to identify impending respiratory collapse note (hypercarbia), and clinical examination to determine if patient is tiring.

2. Support of blood pressure
   a. Norepinephrine infusion started at 0.04 μg/kg/min to achieve MAP of >65 mm Hg
   b. Central venous line placed to decrease risk of tissue necrosis from vasoactive infusion
   c. Arterial line placed to allow continuous blood pressure monitoring
3. Infection control
   a. In the absence of culture data initially, broad-spectrum antibiotics should be started as soon as the diagnosis of sepsis is suspected. Ideally, this would have already occurred in the emergency department.
   b. Blood, sputum, urine, and wound purulent samples should be sent for culture. Although the yield may be greater prior to administration of antibiotics, this should not delay administration of antibiotics.
   c. Once the patient is stabilized, the extent and source of the infection should be determined. In this case, a contrasted CT abdomen and pelvis would likely demonstrate a fluid collection consistent with pelvic abscess.
   d. Depending on the results of the CT, a decision will be made whether to treat only with antibiotics, to ask interventional radiologists to place a drain, to drain the abscess, or proceed to surgical exploration.
   e. Once culture results reveal the causative organism and sensitivities, antibiotic therapy should be narrowed to minimize risk of *Clostridium difficile* infection and formation of resistant bacteria.

# *Discussion*

This patient presents with septic shock likely secondary to a surgical site infection and severe ARDS. Her arterial blood gas shows respiratory acidosis. The treatment approach is to support end-organ function while treating the primary infection. The diagnosis of severe ARDS is made based upon a P/F ratio of 68 ($pO_2$ 68 mm Hg/$FiO_2$ 1.0), bilateral patchy infiltrates on CXR, a known insult (sepsis), and no reason to suspect cardiogenic pulmonary edema. If hypoxemia worsens despite maximal ventilator support, then the following options can be considered in order of preference: (1) prone positioning, (2) neuromuscular blockade, (3) veno-venous extracorporeal membrane oxygenation.

# Patient 2 With Postoperative Hemorrhage

*You are called to assess a 31-year-old female who underwent laparoscopic myomectomy and has been in the postoperative recovery room for 1 hour. Upon arrival, you note that the following vital signs are displayed on the bedside monitor.* Vital signs:

- Heart rate 126/minute
- Blood pressure 96/44 (61)
- Respiratory rate 22/minute
- $SpO_2$ 94% on room air
- Temperature 96.4 °F (34.8 °C)

The patient is complaining of lower abdominal pain. The bedside nurse has given 1 L of lactated Ringer solution since arrival to the postanesthesia care unit, with no increase in blood pressure and a slowly worsening tachycardia.

Differential diagnoses:

- Residual vasodilation from anesthetic agents
- Hypovolemic shock
- Hemorrhagic shock
- Anaphylactic shock

You prepare an operating room for potential reoperation, meanwhile continue to workup the potential cause of your patient's hypotension. A bedside ultrasound assessment demonstrates fluid in the pouch of Douglas, and a point-of-care arterial blood gas shows:

pH 7.36, $pO_2$ 94, $pCO_2$ 38, $HCO_3$ 23, Hgb 6.2 g/dL

You order two units of packed red blood cells immediately and communicate with the anesthesia and OR teams to prepare for an urgent return to the operating room.

# *Discussion*

This case demonstrates postoperative hemorrhage in a gynecologic surgery patient. Her arterial blood gas is normal. There are several elements of this case that warrant discussion:

1. This patient is young and otherwise healthy, and likely has the capacity to compensate for significant blood loss before becoming hypotensive. The first clinical sign of significant hypovolemia is typically tachycardia.
2. Prompt recognition of bleeding is essential.
3. Hypothermia contributes to worsening coagulopathy by impairing platelet aggregation and performance of clotting factors. Patients should be warmed ideally to 97.7 °F (36.5 °C). Note that hypothermia-induced coagulopathy is often missed on routine coagulation laboratory tests as the machines performing the tests typically warm the samples to normal body temperature.
4. Packed red blood cells are stored with citrate added to prevent coagulation in storage. The administration of multiple units of blood cells will result in hypocalcemia due to citrate binding calcium in the patient's own blood and a dilutional coagulopathy.
5. If the resuscitation requires four or more units of red blood cells, then platelets, fresh frozen plasma, and cryoprecipitate should

be given. The ratio of these products can be altered based upon laboratory assessment of clotting function.

## KEY POINTS

- The goal of balanced resuscitation is optimizing fluid status, CO, and SVR to ensure that all organs are optimally perfused.
- Differentiation between types of shock can be established with point-of-care ultrasound.
- ARDS is a severe, multifactorial disorder of lung function that results in alveolar injury and ventilation perfusion mismatch.
- Treatment of ARDS involves addressing the initiating cause and providing supportive treatment to minimize further lung injury. It is imperative to identify the cause of ARD and providing support.
- Septic shock requires prompt and aggressive treatment including early administration of antibiotics, intravascular volume resuscitation, source control (identification and treatment of source of infection), and may progress to requiring administration of vasoconstrictor infusions.
- Postoperative hemorrhage may be missed until the patient becomes hypotensive. A patient who is tachycardic after surgery should be carefully evaluated with a high suspicion for postoperative bleeding.
- Hypothermia worsens bleeding due to disordered coagulation.

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# SECTION IV

# Contemporary Gynecologic Surgical Procedures


14 DILATION AND CURETTAGE
Ronald T. Burkman and Heather Z. Sankey

15 HYSTEROSCOPY
Mindy S. Christianson and Kristin E. Patzkowsky

16 SURGICAL MANAGEMENT OF ABORTION AND ITS COMPLICATIONS
Amy G. Bryant and Chava Kahn

17 SURGERY FOR BENIGN VULVAR CONDITIONS
Heather Z. Sankey and Ronald T. Burkman

18 TUBAL STERILIZATION
Amy G. Bryant and Jessica E. Morse

19 SURGERY OF THE OVARY AND FALLOPIAN TUBE
Sarah L. Cohen Rassier and Antonio R. Gargiulo

20 SURGICAL MANAGEMENT OF ECTOPIC PREGNANCY
Katharine O'Connell White and Paula M. Castaño

21 MYOMECTOMY
Linda D. Bradley and Tommaso Falcone

22 VAGINAL HYSTERECTOMY
John A. Occhino and John B. Gebhart

23 ABDOMINAL HYSTERECTOMY
Laurie S. Swaim and Audra E. Timmins

24 MINIMALLY INVASIVE HYSTERECTOMY-LAPAROSCOPIC AND ROBOTIC-ASSISTED HYSTERECTOMY
Ted L. Anderson and Ronald D. Alvarez

# CHAPTER 14

# DILATION AND CURETTAGE

Ronald T. Burkman and Heather Z. Sankey

**Indications**
**Contraindications**
**Preoperative Evaluation**
History
Physical Examination
Other Preparation for D & C
Role of Imaging
Local Anesthesia
Regional and General Anesthesia
**D & C Procedure**
Positioning
**Dilation and Curettage**
Pelvic Examination
Preparation and Visualization
Cervical Dilation
Management of a Stenotic Cervix
Curettage
Endometrial Biopsy
**Role of Hysteroscopy**

**Immediate Complications**
Hemorrhage
Uterine Perforation
Cervical Injury
**Delayed Complications**
Hemorrhage
Infection
Intrauterine Adhesions
**Management of Anticoagulated Patients**

Dilatation and curettage (D & C) is the oldest known gynecologic procedure. A rudimentary form of the speculum and uterine sound were in use as early as 300 BC. Uterine dilators were described in the 1600s, but it was not until 1843 that Recamier introduced a small spoonlike instrument, which he named the curette. Until the second half of the 20th century, the D & C was the only procedure used to diagnose abnormalities arising in the uterine cavity. However, with the advent of newer office-based endometrial biopsy techniques, hysteroscopy, and transvaginal ultrasound, the D & C is less commonly used for diagnosis. It is still an important procedure for diagnosis in certain situations and for treatment of a number of conditions.

# INDICATIONS

The therapeutic indications for D & C include those that are pregnancy-related such as elective and medically indicated abortions, and management of postpartum hemorrhage and retained products of conception, including placentas. In addition, D & C is performed to initially control bleeding that is unresponsive to hormonal therapy and to treat gestational trophoblastic disease. There are a number of diagnostic indications for either endometrial

sampling or D & C. TABLE 14.1 lists the diagnostic indications for office-based endometrial sampling and D & C in the operating room. TABLE 14.2 lists specific indications for D & C.

## TABLE 14.1
## Indications for Endometrial Sampling[a]

| **Abnormal uterine bleeding** |
|---|
| • Postmenopausal—any bleeding including spotting or brown staining<br>• Age 45 to the menopause—bleeding that is more frequent, heavier, or more prolonged than usual<br>• Less than age 45—abnormal bleeding in high-risk women (obese, chronic anovulatory states such as polycystic ovarian syndrome or bleeding after secondary amenorrhea, presence of Lynch syndrome), persistent bleeding despite medical management<br>• Monitoring women undergoing medical treatment for due to endometrial hyperplasia<br>• Prior to performing an endometrial ablation procedure |
| **Abnormal cervical cytology** |
| • Atypical glandular cells (AGCs) if endometrial and AGC all subcategories in women aged 35 or greater or risk factors for endometrial cancer<br>• Presence of endometrial cells in postmenopausal women.<br>Presence of endometrial cells in premenopausal women with risk factors for endometrial cancer. |

[a]Office-based sampling or D & C.

## TABLE 14.2
## Specific Indications for D & C

- Inability to perform an office-based procedure (patient unable to tolerate, cervical stenosis)
- Insufficient tissue for analysis following office-based procedure or nondiagnostic sample in women at high risk for endometrial cancer
- Persistent abnormal bleeding in a woman after benign findings on an office-based procedure
- With concomitant procedure such as hysteroscopy or laparoscopy

# CONTRAINDICATIONS

There are very few contraindications to D & C. Patients with a significant comorbidity or previous reaction to anesthesia benefit from an anesthesia consult prior to surgery. If there is an ongoing pelvic infection, instrumentation of the endometrial cavity should be avoided until antibiotic treatment has been completed. An exception would be a suction procedure to manage a septic abortion. These cases have been associated with higher risk of uterine perforation, and awareness of this should be heightened.

Women with bleeding disorders such as von Willebrand disease or who are on anticoagulation usually tolerate diagnostic outpatient endometrial sampling with aspiration devices. When a D & C is contemplated for either diagnosis or treatment, consultation with a hematologist is appropriate to decide how to manage excessive bleeding in a woman with a bleeding diathesis and the approach for withholding anticoagulation for women receiving such treatment. Occasionally, endometrial sampling may be required in a woman who has an intrauterine contraceptive device (IUD). This is often performed for surveillance of patients diagnosed with endometrial hyperplasia and treated with a progestin-releasing IUD. Although a D & C would usually require removal, gentle sampling with an aspiration device often can typically be completed without dislodging the device. If a woman has a history of vasovagal reactions with minor procedures such as IUD insertion and removal or with

colposcopy, this is a relative contraindication for an office-based procedure.

# PREOPERATIVE EVALUATION

## History

The history should focus on detailed information that supports the diagnosis and rationale for proceeding with endometrial sampling or D & C. In addition, the history should determine whether there are contraindications to the procedure and whether preoperative assessment from the patient's primary care provider is required. In particular, one should ascertain if she has had procedures involving the uterus or cervix previously and whether there were any complications. If an office-based procedure is being considered, it is important to determine if there are any medical conditions, such as , class III obesity, significant COPD, or allergies to local anesthetics, that would be relative contraindication. In addition, one should determine if the patient has previously undergone office-based procedures, for example, endometrial biopsy, IUD insertion, or colposcopy, and how well she has tolerated the discomfort associated with the procedure.

## Physical Examination

In addition to assessing the overall health status of the patient, the pelvic examination provides important information for the selection of the appropriate procedure. One should note whether the cervix is significantly scarred from either a prior delivery or procedures such as conization. Although the external appearance does not always predict if some degree of cervical stenosis is present, it allows one to counsel women that dilation of the cervix may be required or to pretreat with misoprostol. The position of the uterus should be noted since sounding or dilating the cervix of a sharply anteflexed or retroflexed uterus needs to be performed carefully to avoid perforation. An enlarged uterine size may suggest a diagnosis for abnormal bleeding such as leiomyomata if irregularly enlarged or

adenomyosis if symmetrically enlarged. If a pregnancy-related suction procedure is planned, ascertaining the uterine size helps determine the most appropriate location to perform the surgery safely. The presence of a purulent discharge accompanied by uterine or adnexal tenderness would suggest that an infection is present. If infection is suspected, nonpregnancy-related procedures should be delayed until treatment is completed. However, if the diagnosis is a septic abortion, one should proceed with the procedure since it is a key component of the therapy along with antibiotics.

## Other Preparation for D & C

Preoperative counseling should include discussion of the planned procedure, the indications for the procedure, potential findings and how they would be managed in general, as well as the side effects, risks, and potential complications related to D and C. Advantages of undergoing an office-based procedure or outpatient surgical approaches should be presented relative to their risks and benefits. Anesthesia options should also be discussed. There should be ample time for questions. At the end of the discussion, a formal consent document should be completed. The major points discussed should be documented either on the consent form or in the chart.

For almost all office-based endometrial biopsy procedures, no laboratory testing is needed. Women requiring procedures in the operating room require only the testing that their age or medical conditions dictate.

Prophylactic antibiotics are not required for women undergoing endometrial sampling or a D & C. However, they are commonly used for women undergoing pregnancy-related procedures.

## Role of Imaging

There are several indications for imaging prior to a planned D & C or endometrial biopsy. Postmenopausal women who present with spotting or light bleeding and who wish to avoid a procedure are candidates for a transvaginal ultrasound. If the endometrial thickness

is 4 mm or less, the likelihood of an endometrial cancer is exceedingly low with negative predictive values ranging from 99.8% to 100%. Transvaginal ultrasonography or sonohysterography is indicated in someone who has recurrent or persistent bleeding that has not responded to medical management particularly if one suspects the possibility of a polyp or submucosal leiomyoma. It should be noted that with suspected lesions that encroach into the uterine cavity, a sonohysterogram will better define the lesions than a transvaginal ultrasound. With abnormal bleeding following an endometrial ablation, a sonohysterogram may better define the contours of the uterine cavity, although scarring may make it difficult to insert a catheter into the uterine cavity. Sampling the endometrium may require use of an ultrasound for guidance to locate pockets of endometrial tissue. Use of transvaginal ultrasound is helpful when the D & C is performed for pregnancy-related conditions, for example, to determine gestational age or location of retained tissue. Ultrasonography also allows one to diagnose other entities besides intrauterine pregnancy such as a suspected molar pregnancy and allows for specific counseling. Finally, performing transabdominal ultrasound with a full bladder is also useful when a stenotic cervical os is present and there is uncertainty about the course of the true endometrial canal.

# Local Anesthesia

Women undergoing an office endometrial biopsy will tolerate the procedure without analgesia if properly counseled in advance, by discussing the steps of the procedure as they occur and avoiding cervical dilation or the use of a tenaculum. Women who take an oral nonsteroidal anti-inflammatory drug (NSAID) 30 minutes prior to the procedure will experience less cramping. Placing a paracervical block by injecting 10-20 mL of 1% lidocaine or 1% chloroprocaine circumferentially around the cervix 2-3 cm above the external os at the cervicovaginal junction or at 2, 4, 8, and 10 o’clock will also provide pain relief. Placing 1-2 cc of the local anesthetic at the site of intended tenaculum placement reduces the pain. Recent information suggests that the instillation of local anesthesia into the uterine

cavity is more effecitve: 5 cc of 1% lidocaine is slowly injected over 1 minute into the uterine cavity just below the fundus. Injection can be performed using an endometrial aspiration device cannula or an 18-gauge angiocath. The operator leaves the cannula or angiocath in place for 3-5 minutes to block leakage from the cervical canal before performing the biopsy. Another approach is to use conscious sedation also known as procedural sedation and analgesia or neuroleptanalgesia, which utilizes the administration of sedatives with or without analgesia to reduce procedural discomfort while maintaining cardiopulmonary function. This can be performed in the office if it is equipped to appropriately monitor women during and after the procedure, and trained personnel, equipment, and medications are available to perform advanced cardiopulmonary resuscitation techniques if needed. Otherwise, the procedure needs to be carried out in a procedure area or operating room with anesthesiology support.

## Regional and General Anesthesia

Regional or general anesthesia is often used for women undergoing therapeutic D & C with a large-sized uterus. For women undergoing a diagnostic D & C, the type of anesthesia chosen is important if relaxation is needed such as when significant retraction is planned to visualize the cervix. Since the anesthetic risks are higher for these cases, preoperative assessment or additional laboratory testing may be required for women with underlying medical conditions such as cardiopulmonary disease.

# D & C PROCEDURE

## Positioning

For D & C, patients are placed in the dorsal lithotomy position. Care should be taken in positioning since hyperabduction at the hips can lead to postoperative pain and even femoral nerve injury. The lateral aspect of the legs near the head of the fibula should be padded in

order to avoid pressure on the peroneal nerve. **BOX 14.1** lists steps for performing Dilation and Curettage.

## BOX 14.1 STEPS IN THE PROCEDURE

### Dilation and Curettage

- Place patient in lithotomy position, prep, and then drape.
- Perform pelvic examination to determine uterine position and size.
- Perform paracervical block in conjunction with conscious sedation or use other anesthetic techniques.
- Place tenaculum on the cervix and exert traction to align cervical canal.
- If the procedure is not pregnancy related, sound for direction of the cervical canal; can also ascertain uterine depth.
- Gradually dilate the cervix with Pratt or Hegar dilators.
- For a diagnostic procedure, sample circumference of uterine cavity with a sharp curette.
- If the procedure is performed for retained placenta or postpartum hemorrhage, use a ring or ovum forceps to extract tissue and avoid vigorous curettage of the uterine wall. Ultrasound can determine the location of retained tissue and if continued curettage is necessary.
- Probe with ovum forceps if a polyp is suspected when doing diagnostic procedure.

# Pelvic Examination

A pelvic examination is performed upon induction of anesthesia to ascertain the uterine position in order to determine the direction of the cervical canal as well as the size of the uterus. One should palpate the adnexa to determine their size and consistency. The

cervix is also visualized to determine whether there is evidence of scarring or infection. In past years, a detailed pelvic examination under anesthesia was a significant component of D & C procedures. However, with advances in pelvic ultrasonography, the use of such imaging provides a far better assessment than does a bimanual examination. Thus, if there is any concern about the pelvic anatomy potentially influencing the conduct of a D & C, a pelvic ultrasound should be completed prior to the procedure.

## Preparation and Visualization

The vulva, vagina, and cervix are prepped with an antiseptic solution and drapes are placed over the legs and perineum. An aqueous iodine solution is frequently used as an antiseptic; however, recent data suggest that chlorhexidine provides better protection from infection.

Most D & C and endometrial biopsy procedures can be carried out using a medium Graves speculum to visualize the cervix. For a multiparous woman who has redundant vaginal tissue, a large-sized Graves speculum with increased width and length should be used. With sharply anteflexed or retroflexed uterine positions, Sims or sidewall retractors held by an assistant can aid visualization. Some operators also prefer weighted speculums in combination with Sims or sidewall retractors particularly when the Graves speculum is inadequate for visualization and manipulation of instruments.

With a D & C procedure, a tenaculum is used to grasp the anterior lip of the cervix followed by traction to straighten the cervical canal. If a paracervical block is planned , it can be placed at this time. Occasionally, one will need to grasp the posterior lip due to a sharply retroverted uterus, scarring from surgery or obstetrical trauma obliterating most of the anterior cervical lip. Single-tooth tenacula are commonly used but can lacerate the cervix of postmenopausal women or women with scarred cervices. Further, upon removal of the tenaculum, there can be bleeding from the puncture sites. To avoid this problem, one can use a tenaculum with multiple teeth or even long Allis clamps. Another approach is to use

a single-tooth tenaculum where the points have been “blunted” (**FIG. 14.1**).

**FIGURE 14.1** *Top*: Single-tooth tenaculum. *Bottom*: Long Allis clamp with multiple blunt teeth.

One will occasionally encounter a situation where it is extremely difficult to visualize the cervix even with the use of retractors such as in patients with long vaginas or an obese patient. In such cases, one can insert the fingers from one hand into the vagina to palpate the cervix and follow this with the tenaculum to grasp anterior or posterior lip of the cervix. An assistant is often required to provide traction with sidewall retractors in order to allow the operator to safely complete the procedure in such cases.

# Cervical Dilation

Prior to dilating the cervical canal, one must determine its patency as well as direction. For most cases, one uses a malleable metal sound for this purpose. As an alternative, there are single-use sounds such as the Wallach Flexisound (**FIG. 14.2**), which have smaller diameter tips than do most metal sounds and which also can be bent to conform to the direction of the cervical canal. Prior to sounding, traction is applied to the cervix with the tenaculum to reduce angulation of the canal and to avoid perforation during insertion of instruments as well as to stabilize it. With the sound, the direction of the canal and uterine depth are determined.

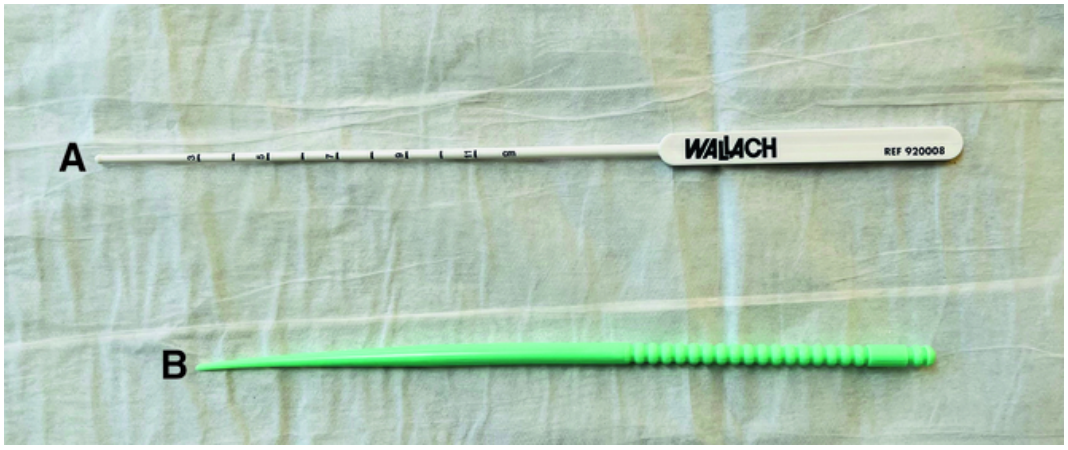


**FIGURE 14.2** *Top*: Wallach Flexisound (Courtesy of CooperSurgical, Inc.). *Bottom*: Os Finder. (Courtesy of CooperSurgical, Inc.)

There are a variety of cervical dilators that can be used for D & C procedures. The most widely used are the Hegar and Pratt dilators. The Hegar dilators have blunt ends and range in size from 1 to 26 mm in diameter (**FIG. 14.3**). The Pratt dilators have tapered ends and range in diameter from 13 to 43 French (3 French units equals 1 mm) (**FIG. 14.4**). Both types have different diameters at the ends to allow one step up in diameter without the need to change to another

dilator. **TABLE 14.3** provides information on the tip diameters of Pratt and Hegar dilators as well as Sims uterine curettes. To proceed with dilatation, the nondominant hand exerts traction on the tenaculum that is applied to the cervix to straighten the canal as much as possible. Using a pencil grip at the midsection of the dilator allows for precise control (**FIG. 14.5**). Starting with the lowest diameter dilator, it is inserted into the os following the direction of the sound. The dilator should just traverse beyond the internal os. The side of the hand holding the dilator can act as a "stop" to avoid inserting the dilator too far. For most diagnostic D & C procedures, dilation to a no. 19 to no. 21 French with Pratt dilators or 5-7 mm with Hegar dilators will provide enough room for insertion of a no. 1 Sims curette or a 5-mm diameter hysteroscope. If the desired curette does not pass though the canal readily, one can dilate one or two additional sizes to allow introduction of the curette.

**FIGURE 14.3** Hegar dilators.

**FIGURE 14.4** Pratt dilators.

## TABLE 14.3
## Diameters of Frequently Used Sims Curettes and Cervical Dilators

| SIMS UTERINE CURETTES | |
|---|---|
| **SIZE** | **TIP DIAMETER (mm)** |
| No. 1 | 7 |
| No. 2 | 8 |
| No. 3 | 9 |
| No. 4 | 11 |
| No. 5 | 14 |
| **PRATT DILATORS[a]** | |
| **SIZE (FRENCH)** | **TIP DIAMETER (mm)** |
| 9/11 | 3.0/3.7 |
| 13/15 | 4.3/5.0 |
| 17/19 | 5.7/6.3 |
| 21/23 | 7.0/7.3 |
| 25/27 | 8.3/9.0 |
| 29/31 | 9.7/10.3 |
| 33/35 | 11.0/11.7 |
| 37/39 | 12.3/13.0 |
| 41/43 | 13.7/14.3 |
| **HEGAR DILATORS[a]** | |
| **SIZE** | **TIP DIAMETER (mm)** |
| 3/4 | 3.0/4.0 |
| 5/6 | 5.0/6.0 |
| 7/8 | 7.0/8.0 |
| 9/10 | 9.0/10.0 |
| 11/12 | 11.0/12.0 |
| 13/14 | 13.0/14.0 |
| 15/16 | 15.0/16.0 |
| 17/18 | 17.0/18.0 |

[a]Dilators have different diameters on each end.

**FIGURE 14.5** Poising hand on perineum gives stability and control when performing initial sounding.

## Management of a Stenotic Cervix

If a cervix is stenotic, a no. 11 scalpel blade can be used to puncture the stenotic dimple by making a small cruciate incision (**FIG. 14.6**).

When there is difficulty sounding the cervical canal, for example, resistance is encountered at a level of 2-3 cm of depth, one can pass lacrimal duct probes, narrow-gauge Hegar metal dilators (1-4 mm), or an Os Finder in an effort to identify both the opening and direction of the cervical canal. The latter is for single use and has a taper from 2 to 4 mm. If resistance is still encountered, it is important to not use undue force in order to prevent perforation or creation of a false canal. At this point, transabdominal ultrasound should be performed to identify the cervical canal and guide the insertion of dilators. If one suspects a stenotic cervical canal prior to the procedure, a cervical ripening agent such as misoprostol 400 µg by mouth may be used several hours prior to the procedure, although a recent review questions its usefulness.

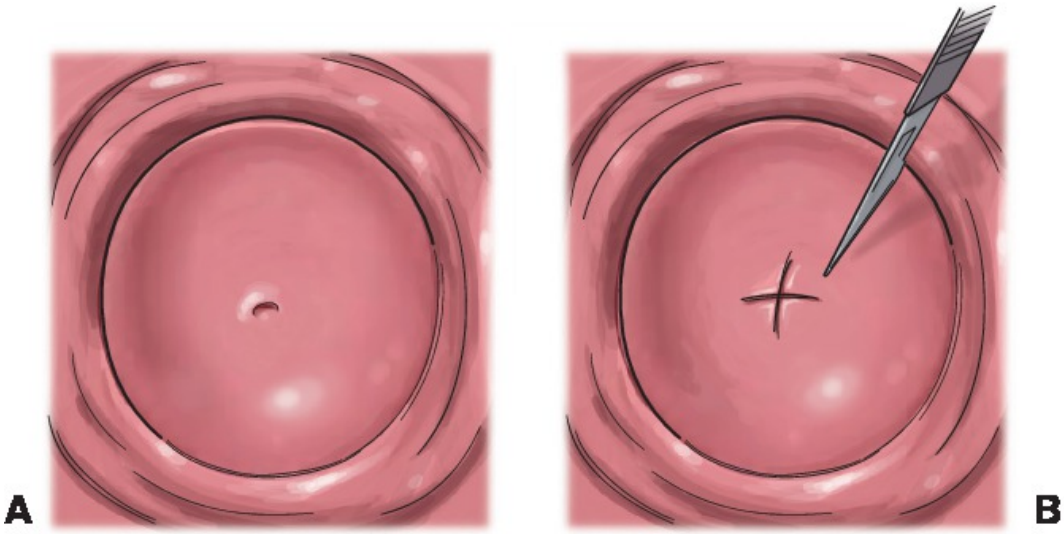


**FIGURE 14.6** Cruciate incision for stenotic cervical os.

# Curettage

There are numerous types of instruments that can be used to curette or sample the endometrium, evacuate products of conception and

molar pregnancies, and manage incomplete abortion or retained placentas.

Suction curettage utilizes a plastic cannula attached to suction machine and is most often used for pregnancy-related conditions and management of molar pregnancies.

Curettes for traditional D & C are metal. Their shafts are malleable and can be bent to optimize the angle of approach for D & C (**FIG. 14.7**). The curette is grasped at the handle with a handshake grip (**FIG. 14.8**). It is inserted to the fundus, and using pressure exerted by the forefinger or tilting the wrist up, the curette is pulled down toward the internal os. Gauze, or a non-adherent pad such as Telfa™ is placed in the vagina to capture the endometrial tissue. The curette is rotated around the circumference of the uterus to collect as much tissue as possible. Despite being systematic in this manner, data from a study of 50 women undergoing prehysterectomy D & C indicated that less than three-fourths of the endometrial cavity was adequately sampled 84% of the time. However, endometrial disorders that tend to be global such as endometrial cancer are successfully detected the vast majority of the time Polyp forceps are inserted to remove possible polyps (**FIG. 14.9**). Occasionally, one encounters a patient for whom the cervix still cannot be adequately visualized despite multiple attempts and using the technique described in the section on prep and cervix visualization. With such patients, one can try to pass a small aspiration device along the fingers of the nondominant hand, palpate the external cervical os, and insert the device into the uterine cavity to aspirate tissue.

**FIGURE 14.7** Sims uterine curettes, size 1 and 2.

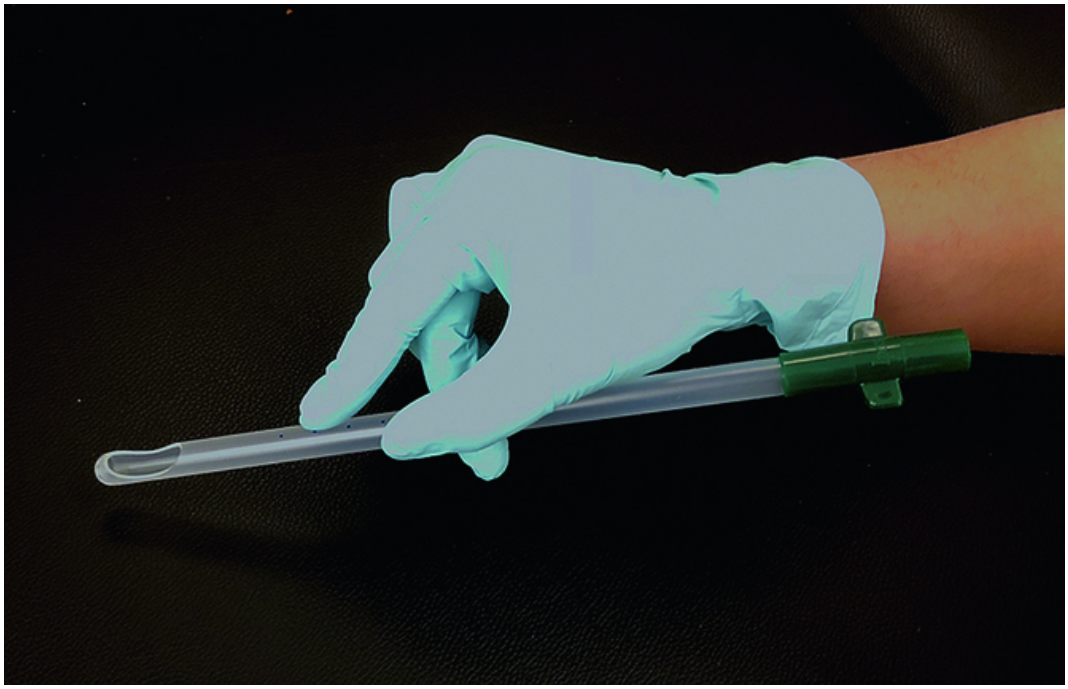

**FIGURE 14.8** Handshake grip.

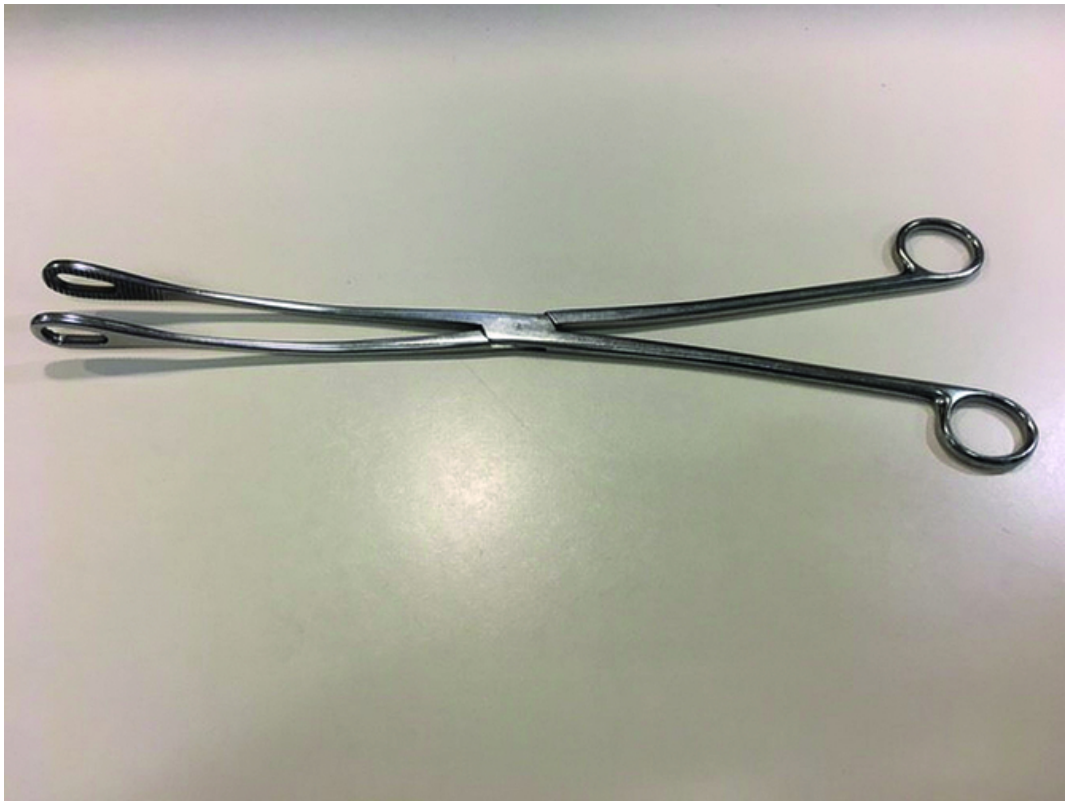

**FIGURE 14.9** Polyp forceps.

## Endometrial Biopsy

Office-based endometrial sampling has substantially reduced the use of the D & C for diagnostic purposes. Patients undergoing an endometrial biopsy are positioned in stirrups on an examining table with the buttocks at the table edge to facilitate placement of the speculum or other instruments. After the bimanual examination, a speculum is inserted to visualize the cervix and the cervix is then prepped with an antiseptic solution. For endometrial biopsy, small-diameter plastic devices provide suction to remove tissue. They may consist of a thin sheath surrounding a plunger, for example, Pipelle device (**FIG. 14.10**). This device can usually be inserted into the uterine cavity without prior cervical dilation and often without the need to use a tenaculum or sound since the device itself has markings, which allows one to determine the depth of the cavity. Once it is inserted beyond the internal cervical os, it should be gently advanced until the uterine fundus is reached. The operator pulls back on the plunger in one rapid, smooth motion to create suction and, using a to and fro motion while rotating the device, samples the uterine wall circumferentially. It is important to keep the device in the uterine cavity in order to maintain suction. The device can be reinserted, if the amount of tissue seems inadequate with the first pass, as long as it is kept sterile. Other devices use syringes to provide suction and to collect tissue. As an example, the EndoSampler (**FIG. 14.11**) consists of a semirigid plastic tubing 3 mm in diameter with a sharp edge at its tip attached to a syringe. This device usually does not require prior cervical dilation or use of a tenaculum. Once inserted to the uterine fundus, the clinician pulls back on the syringe plunger to create suction and uses a to and fro motion to extract tissue, making sure the entire circumference is sampled. Another type of device uses a brush to sample the endometrium, for example, the Tao brush. The device has a sheath surrounding a brush located at the device's tip. The device is inserted until the tip is at the fundus, the sheath is then pulled back,

and the brush is rotated several times to obtain an endometrial sample. The sheath is then pushed back and the device is removed. If one has difficulty inserting an endometrial sampling device beyond the internal os of the cervix, as discussed previously, an Os Finder or other small-diameter instruments can be used to identify and dilate the internal os. At the end of the procedure, the patient is observed for a period of time to detect a vasovagal reaction before she is allowed to leave the office. Vasovagal reactions that occur in conjunction with the procedure may produce symptoms such as of light-headedness, sweating, and nausea, but they rarely progress to syncope. When this occurs, blood pressure should be monitored while leaving the patient supine until the symptoms disappear. Further treatment is usually not needed. NSAIDs can be used to treat uterine cramping, which may last for about a day.

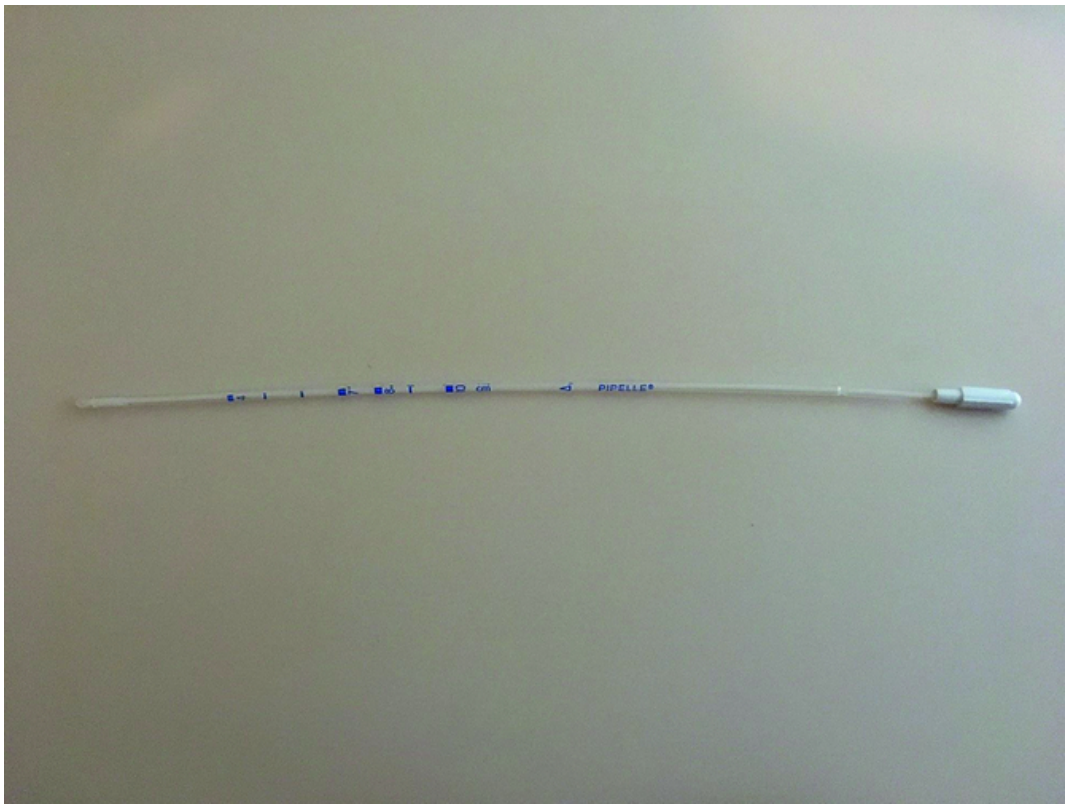

**FIGURE 14.10** Pipelle. (Courtesy of CooperSurgical, Inc.)

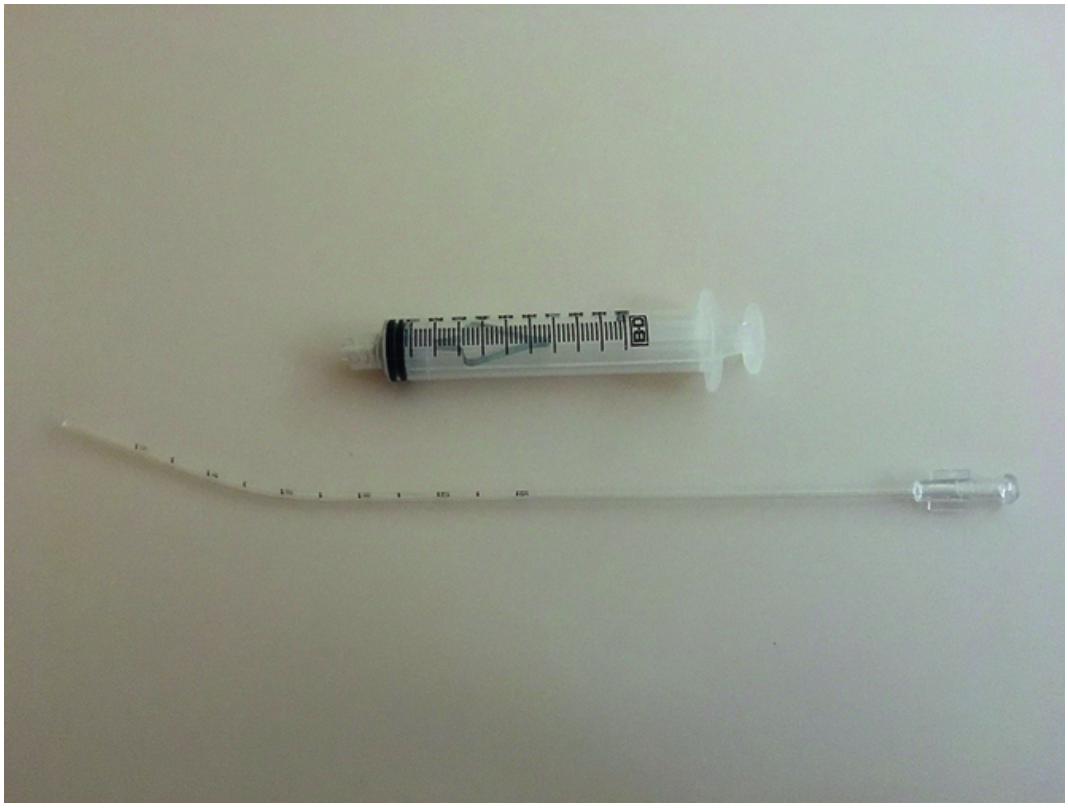

**FIGURE 14.11** EndoSampler. (Courtesy of MedGyn Products.)

## ROLE OF HYSTEROSCOPY

Hysteroscopy in conjunction with a D & C should be strongly considered in women at increased risk for endometrial cancer. In particular, this would include at-risk women whose bleeding persists after undergoing a nondiagnostic endometrial biopsy or who have persistent bleeding with a thin endometrium as seen on ultrasound. Hysteroscopy would allow one to identify and biopsy focal lesions as opposed to those that are more global. Hysteroscopy would also allow one to determine if a polyp or submucosal leiomyoma is the likely cause of abnormal bleeding. Since such lesions can be treated at the same time, the procedure often needs to be carried out in a facility where general anesthesia is available.

# IMMEDIATE COMPLICATIONS

## Hemorrhage

Significant bleeding associated with a D & C occurs when the procedure is performed for pregnancy-related problems or management of molar pregnancy. Using uterotonic medications and ensuring that all placental or trophoblastic tissues are removed will decrease the risk of heavy bleeding. Usually, the bleeding will subside at the conclusion of the procedure, but sometimes one may have to resort to intravenous estrogen such as equine-conjugated estrogen (25 mg IV with a repeat dose in 4 hours if needed) to control the bleeding. Rarely, one may need to pack the uterus or provide tamponade with a Foley catheter bulb to control hemorrhage.

## Uterine Perforation

Uterine perforation, although uncommon, is the most frequent complication associated with D & C. Risk factors for perforation include pregnancy; menopause; cervical abnormalities (cervical stenosis, distorted endocervical canal); sharply retroverted or anteverted uteri; distortion of the uterine cavity due to lesions such as myomas, adhesions, or congenital abnormalities; and hysteroscopy or endometrial ablation performed in conjunction with a D & C. For pregnancy-related procedures, the risk of perforation is 0.5% when termination or incomplete abortion is managed in the first or second trimester. Older studies suggest that the rate of perforation can be as high as 5% when managing postpartum hemorrhage. However, it is likely that the rate is now lower since many such cases are managed with the assistance of ultrasound guidance. During diagnostic procedures, in premenopausal and menopausal women, the rates of uterine perforation have been reported as 0.3% and 2.6%, respectively. Perforation noted during cervical dilation or sounding usually does not require hospitalization or additional management unless hemorrhage occurs. If it is important to complete the procedure or if one suspects significant bleeding from

the perforation site, laparoscopy can be performed to observe and potentially cauterize the uterine site of perforation and evaluate other sites for potential perforation while the curettage portion of the procedure is completed. If perforation is noted during curettage with either sharp or suction instruments or during use of cautery devices, laparoscopy is performed to evaluate potential bowel injury. If there is uncertainty regarding the adequacy of visualization of potential injury using laparoscopy, then a laparotomy is indicated. This is especially important if there is concern for a possible intestinal injury, and this cannot be excluded with laparoscopic evaluation.

**BOX 14.2** summarizes recommendations for management if sharp perforation is fundal, and **BOX 14.3** summarizes management recommendations if the perforation is lateral.

## BOX 14.2 MANAGEMENT OF SUSPECTED SHARP PERFORATION AT FUNDUS

- Alert operative team to possible perforation.
- Call for laparoscopic equipment to be immediately available.
- Monitor vital signs for drop in blood pressure, rise in pulse, and uterine blood loss.
- Examine tissue for any signs of bowel tissue or fat that would indicate damage to other organs.
- If patient is stable, and procedure is complete, the patient may manage expectantly.
- Consider diagnostic laparoscopy to assess bleeding and/or injury to other organs and/or for guidance to complete procedure. Diagnostic laparoscopy should be performed if there is any concern for internal bleeding and/or injury to other organs and/or if needed for guidance to complete procedure.

## BOX 14.3 MANAGEMENT OF SUSPECTED LATERAL PERFORATION

- Immediately alert OR team and monitor vital signs for early signs of shock.
- Call in backup if no surgical assistant present.
- Call for laparoscopic and/or laparotomy equipment.
- Proceed to laparoscopy.
- Assess availability of vascular surgery.
- If patient at any point appears unstable, perform a laparotomy for possible vascular injury.
- Laparoscopy may be the first step in further evaluation if the patient is relatively stable and the surgeon and team have expertise in laparoscopy. If laparoscopic approach is not adequate for assessment of injured area, proceed to laparotomy.

# Cervical Injury

Cervical injury can occur during traction of the cervix or with the creation of false channels during dilation. Excess traction, particularly with a single-tooth tenaculum, can lacerate the cervix. Bleeding from small lacerations can usually be controlled with pressure or application of silver nitrate or Monsel solution. Larger lacerations may require sutures. False channels may occur with excessive force during dilation, failure to provide traction on the cervix to better align the cervical canal, or failure to follow the direction suggested by the uterine sound. When there is inadequate sampling of endometrial tissue, one should suspect the instruments have not been passed beyond the internal os of the cervix or a false channel has been created. Rarely, particularly in suction curettage abortion procedures, creation of the false channel can lacerate branches of the uterine artery or veins leading to significant

hemorrhage. Treatment includes placement of sutures similar to a cerclage or high along the lateral aspect of the cervix. It is important to avoid placing wide lateral sutures, which may inadvertently ligate the ureter. Diagnostic laparoscopy can be used to assess the bleeding and, if necessary, to place sutures and achieve hemostasis.

# DELAYED COMPLICATIONS

## Hemorrhage

Delayed hemorrhage occurs when there is incomplete evacuation of placental tissue at the time of D & C performed for pregnancy termination, incomplete abortion, or management of a retained placenta. Initial management includes treatment with a uterotonic agent such as Methergine or misoprostol. Occasionally, women with false channels will rebleed and require further surgery to control bleeding.

## Infection

Infection following a D & C procedure is exceedingly uncommon such that antibiotic prophylaxis is not routinely recommended. The development of endometritis is rare. The risk of infection is increased when there is retained placental tissue following a D & C performed to manage a pregnancy-related condition such as septic abortion.

## Intrauterine Adhesions

Intrauterine adhesions, also known as Asherman syndrome, develop as a result of substantial denuding of the endometrium during a D & C procedure. The vast majority of cases occur when the D & C is performed for a pregnancy-related condition. Avoidance of too vigorous curettage or use of suction devices or blunt curettes reduces the likelihood of this complication. Use of ultrasound can help identify whether placental tissue remains in order to avoid excessive curettage.

# MANAGEMENT OF ANTICOAGULATED PATIENTS

In general, women taking anticoagulants such as warfarin or the newer direct oral anticoagulants (DOACs), for example, dabigatran, rivaroxaban, apixaban, and edoxaban, do not need to discontinue their anticoagulation therapy prior to an endometrial biopsy or D & C. The risk of significant bleeding with these procedures is low compared to the risk and morbidity of thromboembolism if anticoagulation is stopped. For women on warfarin, an international normalized ratio (INR) should be checked to ensure that it does not exceed the usual therapeutic range. However, since standard coagulation testing has not been shown to predict the level of anticoagulant effect in patients taking DOACs, such testing should not be performed for these patients. In the rare instance of persistent or significant uterine bleeding following the procedure, the endometrial cavity can be packed with gauze or a Foley catheter balloon inserted to achieve tamponade. If these measures are ineffective, consideration can be given to tranexamic acid administration and temporarily discontinuing anticoagulation.

## KEY POINTS

- Diagnostic D & C is performed when other sampling techniques such as office biopsy fail to provide adequate tissue for diagnosis or cannot be completed.
- Most procedures can be completed using a paracervical block with sedation.
- Use of appropriate instruments and attention to surgical technique reduce the risk of a complication.
- When performing a difficult D & C, the surgeon needs to be aware of possible uterine perforation and be ready to perform laparoscopy to assess for intra-abdominal complications.

- A no. 11 blade can be used to puncture the dimple of a stenotic cervical os.

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# CHAPTER 15

# HYSTEROSCOPY

Mindy S. Christianson and Kristin E. Patzkowsky

**Instrumentation**
Telescopes
Camera
Light Generators
Diagnostic and Operative Sheaths
The Flexible Hysteroscope
**Distension Media and Fluid Management**
Liquid Media
Gaseous Media
**Preoperative Considerations**
**Office Hysteroscopy**
**Diagnostic Hysteroscopy**
**Operative Hysteroscopy**
Electrosurgical Devices and Lasers
**Specific Procedures in Hysteroscopic Surgery**
Hysteroscopic Myomectomy
Uterine Polyps
Septate Uterus
Intrauterine Adhesions

Cannulation of the Fallopian Tube
Sterilization
Endometrial Ablation
Miscellaneous Procedures
**Complications**
Uterine Perforation
Management of Fluid Overload
Intraoperative and Postoperative Bleeding
Poor Visibility in the Operative Field
Gas Embolus
Infection
Equipment Failure
**Postoperative Considerations**

Derived from the Greek words *hystera* (uterus) and *skopeo* ("to view"), hysteroscopy is visual examination of the cervical canal and uterine cavity with an endoscope. Pantaleoni performed the first hysteroscopy in 1869 using a tube with an external light source to diagnose a polypoid uterine growth in a 60-year-old woman with postmenopausal bleeding. Today, hysteroscopy is considered the gold standard to evaluate the uterine cavity. This surgical technique allows visualization of the cervical canal and uterine cavity using an instrument that commonly includes a metallic sheath and a telescope receiving light through a fiberoptic bundle from an external illuminating source. A distension media expands the uterine cavity during the procedure.

Over the past 150 years, advances in optics, instrumentation, and distension media have paved the way for new hysteroscopic techniques for diagnosis and treatment of intrauterine cavity disorders. Commonly performed procedures utilizing hysteroscopy include diagnostic hysteroscopy, tubal sterilization, polypectomy,

myomectomy, and excision of uterine septa. In many cases, submucosal myomas no longer require hysterectomy because they can be satisfactorily excised by operative hysteroscopy.

Hysteroscopic surgery requires practice and skill. Hysteroscopic simulation systems facilitate development of hand-eye coordination and procedural orientation. Several computer-based models with advanced interactive graphics provide sophisticated models for learners to excise myomas, ablate endometrium, and pass cannulas into tubal ostia (**FIG. 15.1**). However, simulation does not provide experience with the safe insertion of the scope into the uterine cavity followed by satisfactory distension of the cavity. This skill is fundamental and must be learned *in vivo*; without this skill, hysteroscopy cannot be safely and successfully performed.

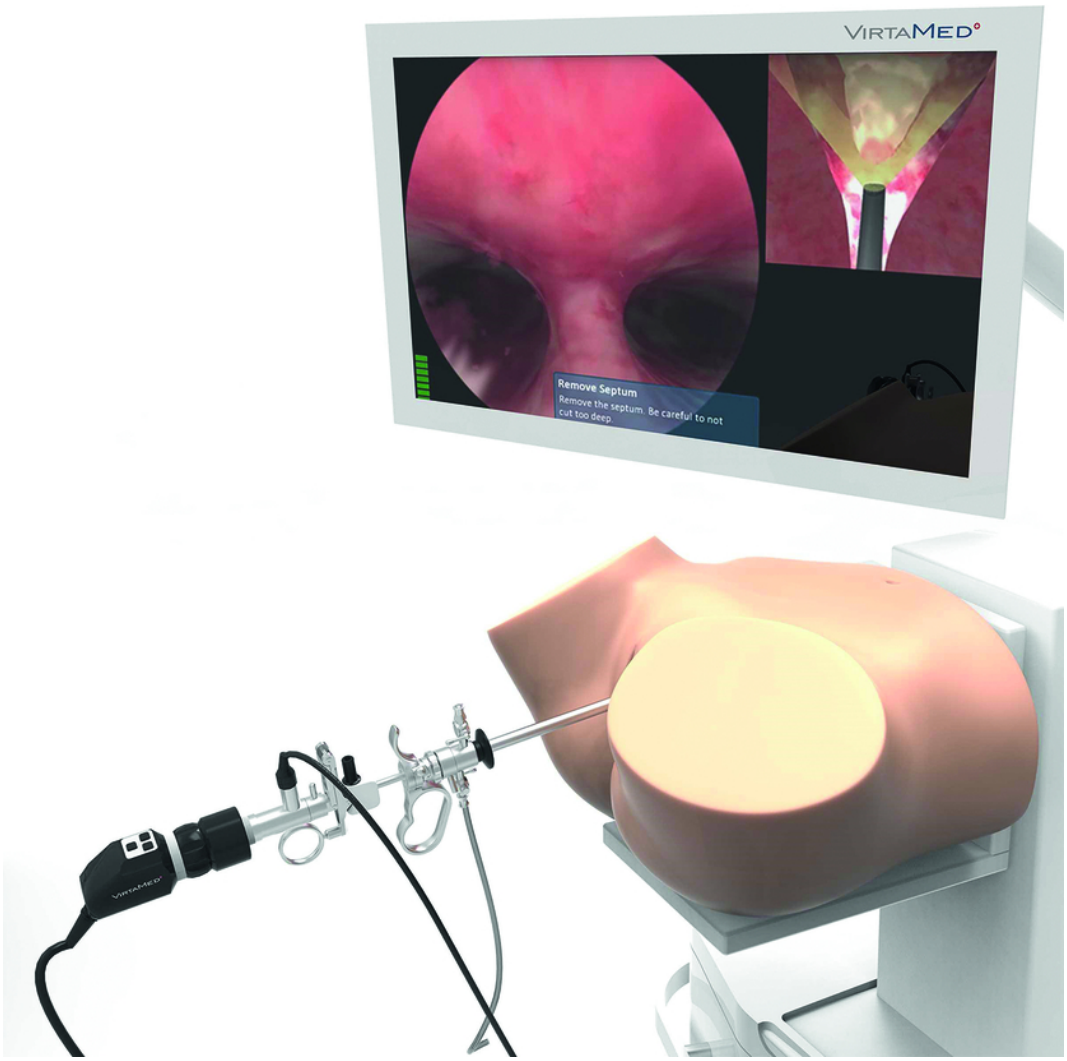


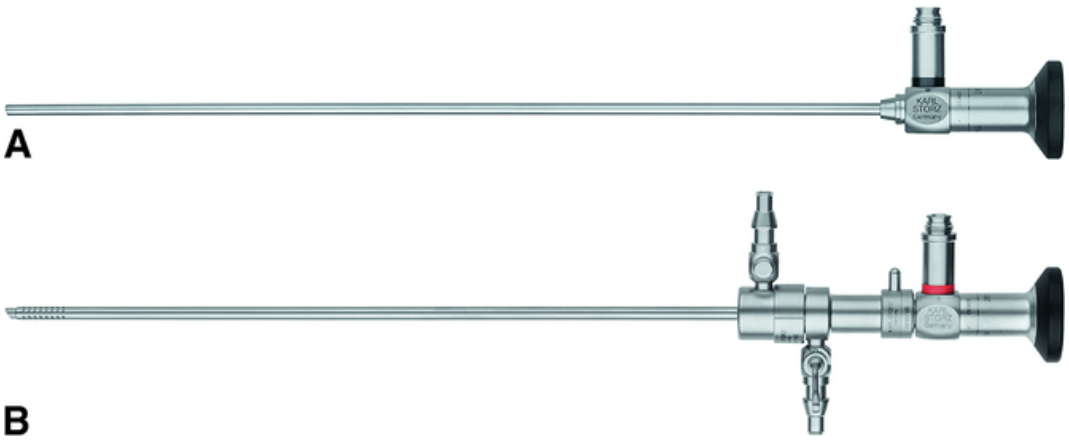

**FIGURE 15.1** Computerized simulation permits the gynecologist to interact by manipulating a hysteroscopic morcellator and resecting a virtual submucosal myoma or polyp. The equipment used is very similar to hysteroscopy equipment in use today. (Reprinted with permission from Virtamed AG, Switzerland.)

# INSTRUMENTATION

Key components of a hysteroscope system include the telescope, camera, light source, operating sheaths, and distension media. Hysteroscopes are classified as rigid or flexible, possessing fixed or variable focus, and are designated for either diagnostic or operative use. Key characteristics of instrumentation that influence use include scope diameter, lens offset, sheath diameter, and ability to use either bipolar or monopolar cautery. While viewing through a hysteroscopic telescope may still be done with the naked eye, today visualization is provided in most cases with a camera and video screen.

## Telescopes

The telescope includes three parts: the eyepiece, barrel, and objective lens. The most desirable optics provide a large field that subtends an angle of ~105°. The 4-mm telescope (lens) is a popular choice, providing a sharp, clear image with a small outside diameter (**FIG. 15.2**). Some contemporary 3-mm-diameter telescopes provide comparable views. These 3-mm-diameter telescopes, coupled to endoscopic video systems with zoom lenses, are highly satisfactory for both diagnostic and operative hysteroscopies.



**C**

**FIGURE 15.2** **A.** Two common 4-mm telescopes are shown here. *Top* is a 12° telescope, and the *bottom* is a 30° telescope. **B.** Telescopes must couple to a 5-mm sheath to be practically functional. The distension medium gains access to the uterine cavity via the inner sheath, and fluid exits the uterus via the outer sheath. (**A, B.** © KARL STORZ SE & Co. KG, Germany.) **C.** Instrumentation for hysteroscopic procedures. From *top down*: outer sheath of the diagnostic scope; the inner

sheath of the diagnostic scope (not coupled together); operative sheath that includes inflow, outflow, and an instrument port; 4-mm telescope capable of insertion into either the operative sheath or diagnostic sheath. (**C.** Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

Telescopes are available in a variety of viewing angles, with the 0° (straight-on) or a 30° fore-oblique view being the most commonly used (**FIG. 15.3**). Other available viewing angles include 12°, 15°, and 70°. The major advantage of the 0° lens is that it allows the operator to visualize the uterine interior as a panorama, whereas this view is lost when a 30° lens is used. However, a 30° lens facilitates visualization of tubal ostia.

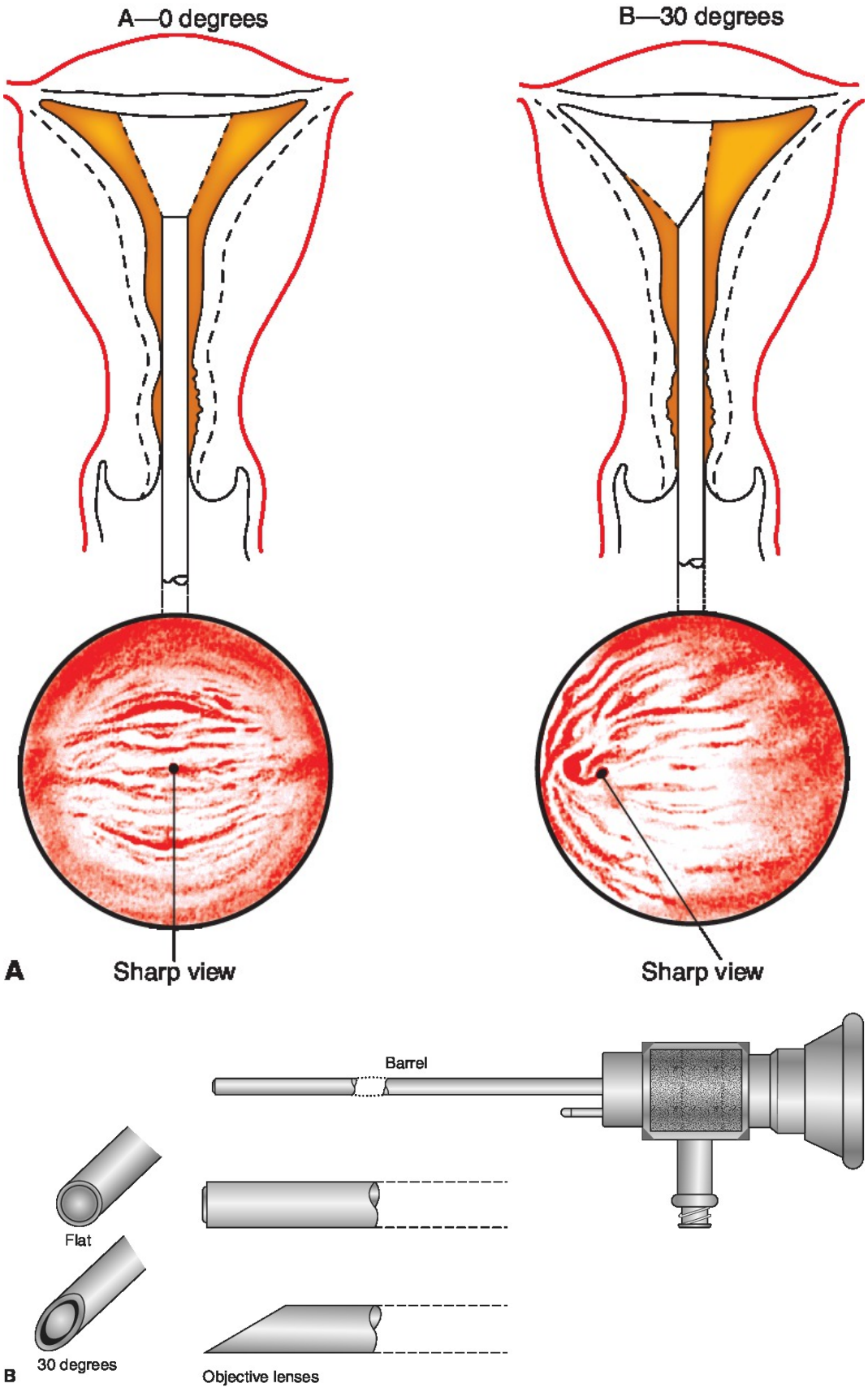

A—0 degrees
B—30 degrees
Sharp view
Sharp view
A
Barrel
Flat
30 degrees
Objective lenses
B

**FIGURE 15.3** **A.** Telescopes are available with either straight-on (0°) or fore-oblique (30°) viewing objective lenses. **B.** A telescope can be conveniently subdivided into three parts: eyepiece, barrel, and objective lens. (Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

## Camera

In most cases today, hysteroscopy employs an endoscopic microchip camera coupled directly to the telescope, with digital recorders. Endoscopic camera lenses range in focal length from 25 to 38 mm. A 28- to 30-mm lens provides satisfactory magnification. The view with a coupled camera provides magnification comparable to that obtained during microsurgery.

## Light Generators

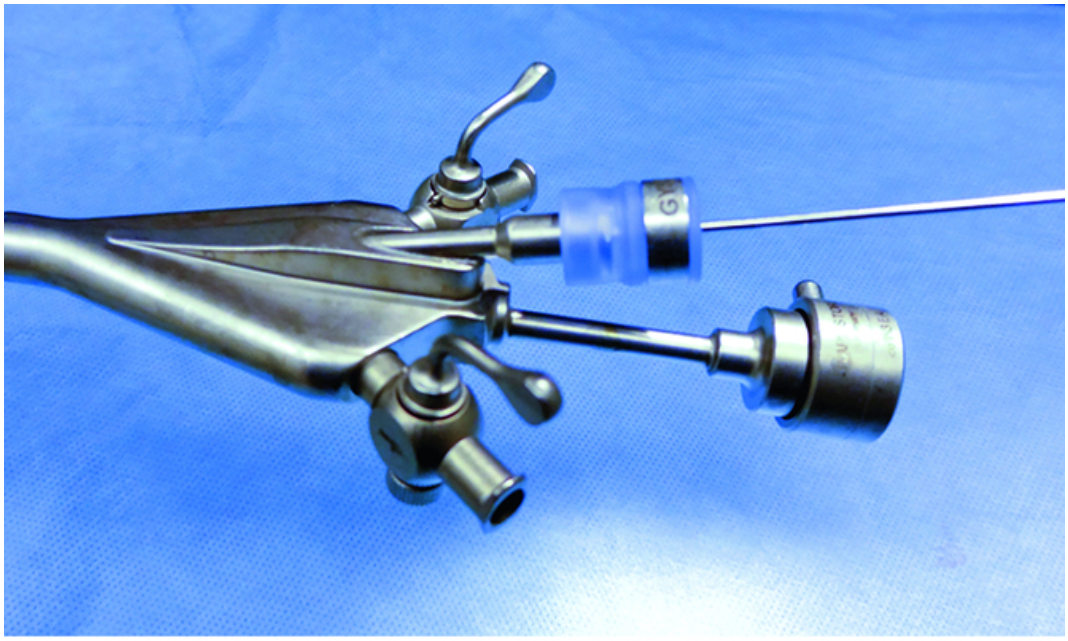
The quality and power of light delivered to the telescope are determined by three factors: wattage, the remote light generator, and connecting fiberoptic light cable. Three general types of light generators are available: tungsten, metal halide, and xenon. A xenon light generator provides the best illumination for video techniques, although less expensive light sources may be satisfactory when coupled to newer cameras, which are highly light sensitive. The fiberoptic light cable is an important component; the cable must be intact to convey the optimal light from the generator to the telescope. Broken fibers can be easily identified by viewing the stretched-out

cable against a dark background and looking for light emitting through the sides of the cable.

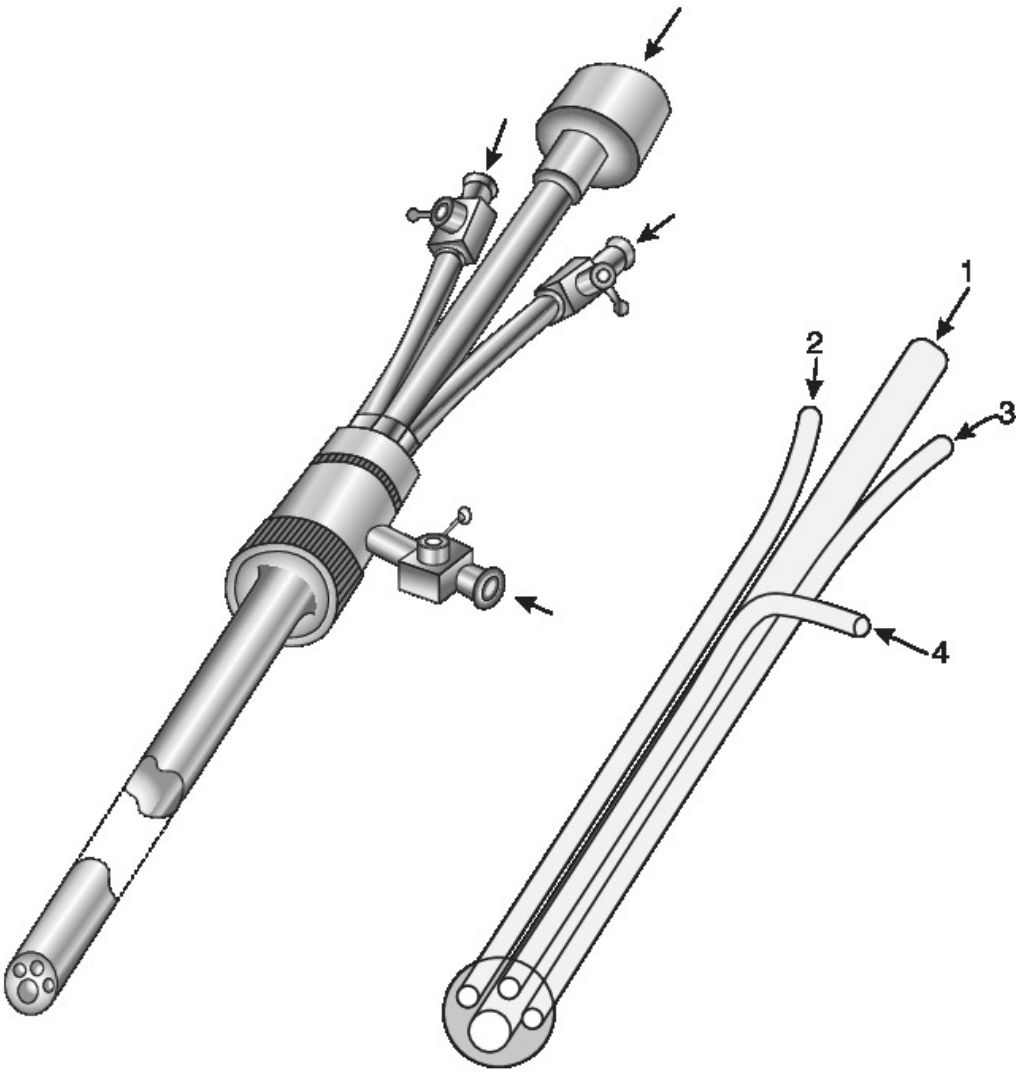
# Diagnostic and Operative Sheaths

A diagnostic sheath is required to deliver distension media into the uterine cavity. The telescope fits into the sheath and is secured by a watertight seal that locks into place. The sheath may be 4-5 mm in diameter, depending on the outer diameter of the telescope, with a 1-mm clearance between the inner wall and the telescope, through which either carbon dioxide ($CO_2$) or liquid distension media is transmitted. Media instillation into the sheath is controlled by an external stopcock. Imprecise or loose coupling between the telescope and sheath will allow media leakage.

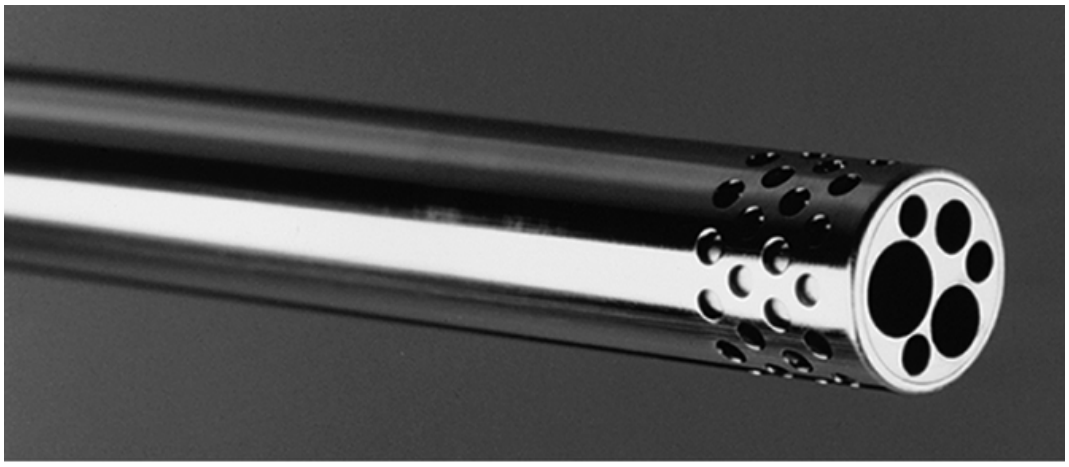
Operative sheaths have a larger diameter than diagnostic sheaths, ranging in size from 7 to 10 mm. The standard operative sheath allows space for instillation of media, the 3- to 4-mm telescope, and operative instruments. The operating channel is sealed with a rubber nipple or gasket to prevent leakage of distension media (**FIG. 15.4 A and B**). Disadvantages of this type of sheath include inability to flush the uterine cavity with the distension media and difficulty manipulating operative tools within the cavity. Hysteroscopes with dual operating channels permit flushing of the cavity as well as improved manipulation of operating accessories. A popular model is the isolated channel sheath consisting of a double-flushing sheath that permits media instillation with the inner sheath and media return via the perforated outer sheath (**FIG. 15.4 C and D**). Constant media flow in and out of the cavity creates a very clear operative field. The single isolated operating channel has a sufficient diameter (3 mm) to permit larger, sturdier operating tools to be used.



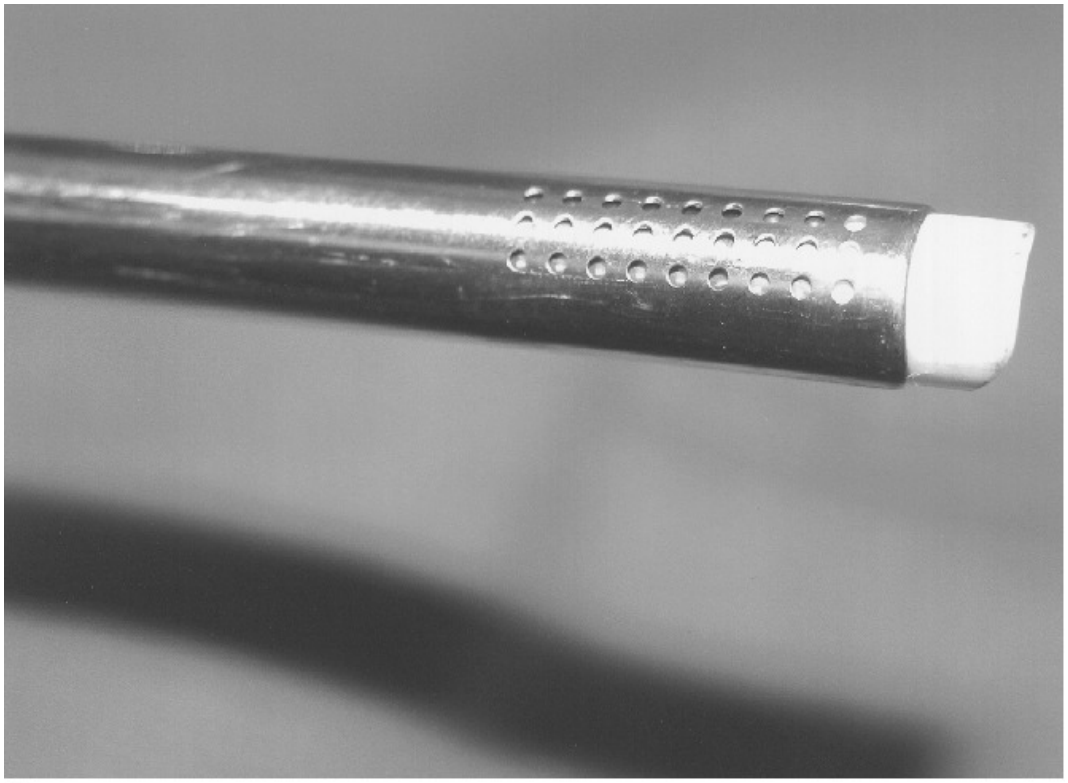
**A**



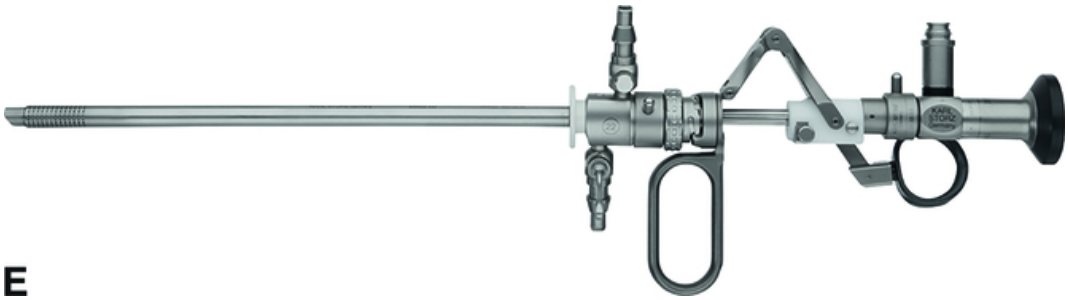

B



C



D



E

**FIGURE 15.4** **A.** An operating sheath with input and output channels as well as flushing capability. The operating channel is sealed with a rubber nipple and has a 7-F instrument inserted. **B.** A dual-channel operating sheath is constructed with (*1*) isolated channels for a telescope, (*2* and *3*) two operating devices, and (*4*) distension media. **C.** The double

sheath mechanism of the isolated channel hysteroscope. The perforations in the outer sheath are for fluid return. The uterus is continuously flushed. **D.** The terminal portion of the sheath shows the output external sheath. Fluid enters through the inner sheath (terminus white). **E.** This 7-mm bipolar resectoscope (with a 12° telescope) allows use of normal saline as the insufflating media (also available in 8.5 mm diameter) (© KARL STORZ SE & Co. KG, Germany.)

The resectoscope (**FIG. 15.4 E**) is a specialized electrosurgical (monopolar or bipolar) endoscope that includes a double-armed electrode, fitted to a trigger device that pushes the electrode out beyond the sheath and then pulls it back within the sheath. The operating tools consist of four basic electrodes: a cutting loop, ball, button, and angulated needle (**FIG. 15.5 A-D**). The resectoscope possesses an inner sheath with a common channel for the telescope, fluid media, and electrode. An outer sheath allows fluid return as described above. Most resectoscopes are equipped with a 30° telescope with the lens angled toward the electrode to permit a clear view of the operative field. Vision of the electrode is lost when the electrode is fully extended outward. Most operating sheaths measure 8 mm or more in outer diameter, so cervical dilatation is usually required for insertion. Contemporary small-diameter resectoscopes use a 3-mm telescope and a 7- to 7.5-mm sheath.

A

B

C

D

**FIGURE 15.5** **A.** The cutting loop electrode is the instrument for shaving submucosal myomas. **B.** The ball or barrel electrode is the instrument most utilized for endometrial ablation. **C.** The button electrode is specifically employed to point coagulation. **D.** The angulated needle electrode is favored for fine cutting such as adhesions or pedunculated myomas.

Standard hysteroscopic tools include 7-F (ie, 2.3-mm) alligator grasping forceps, biopsy forceps, and scissors (**FIG. 15.6**). The small size of these semirigid instruments makes them particularly fragile, as excessive torque at the junction of the shaft and handle frequently leads to breakage. Development of the large isolated channel sheath has made the use of flexible 3-mm operating instruments feasible. Flexible devices are preferred to semirigid devices, in that they are less likely to fracture but are equally facile.

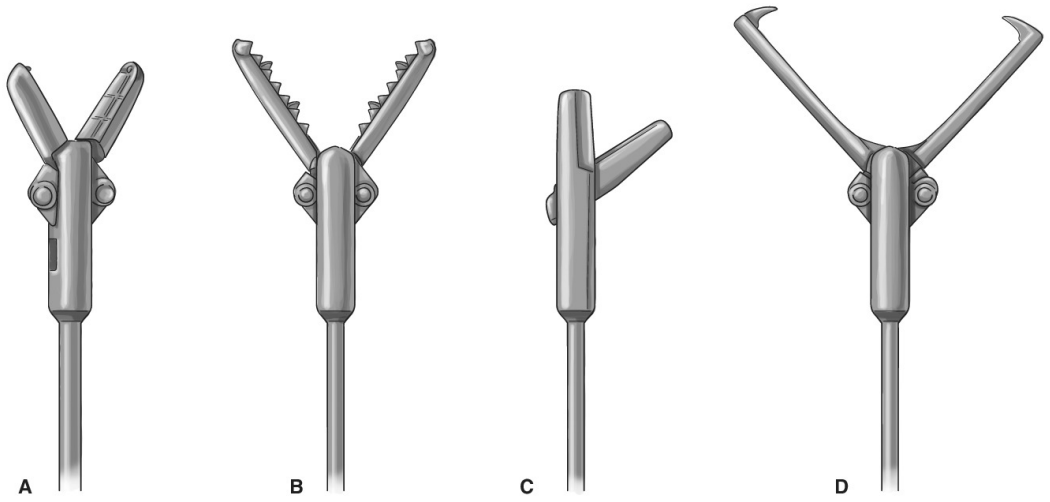
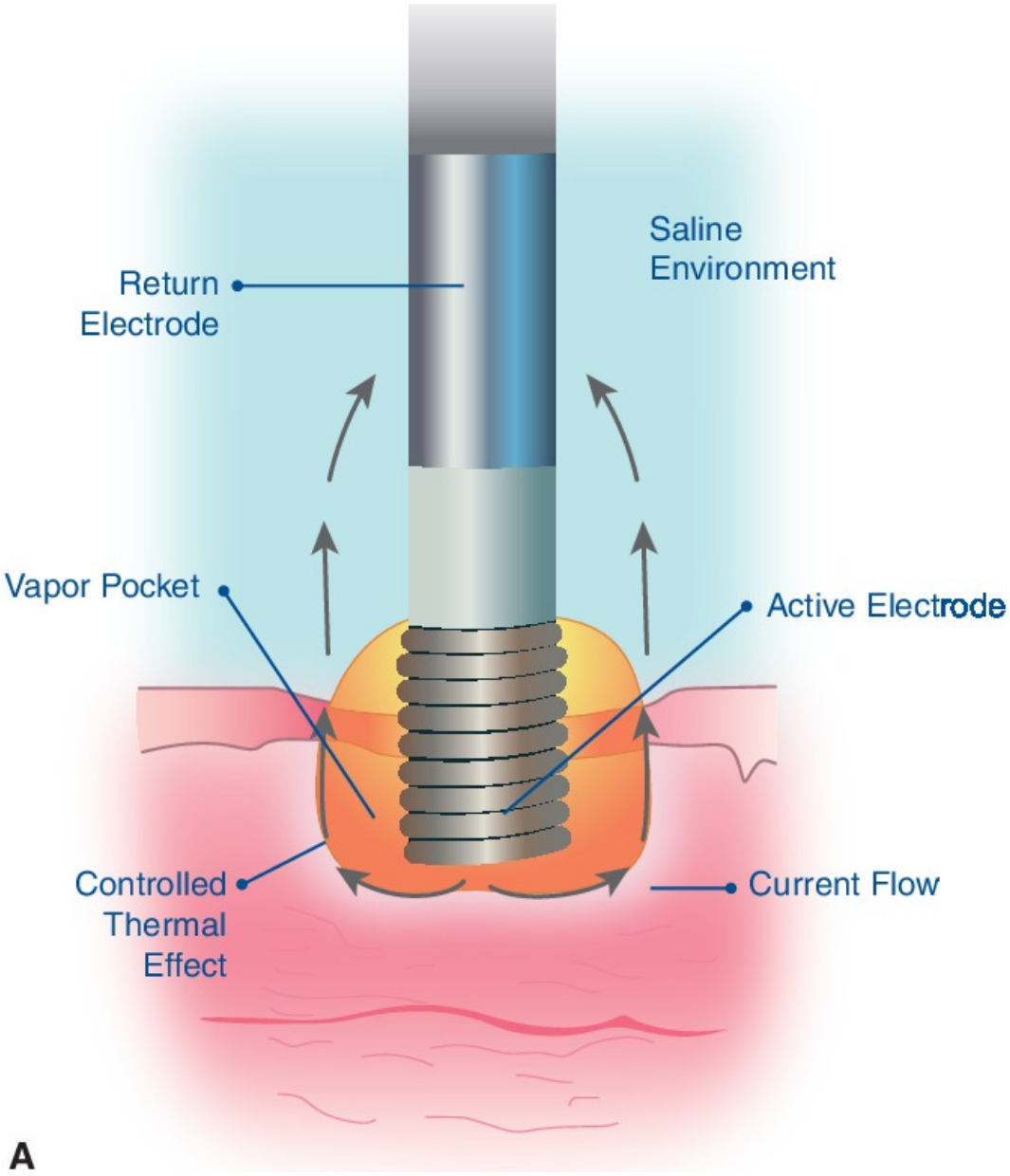


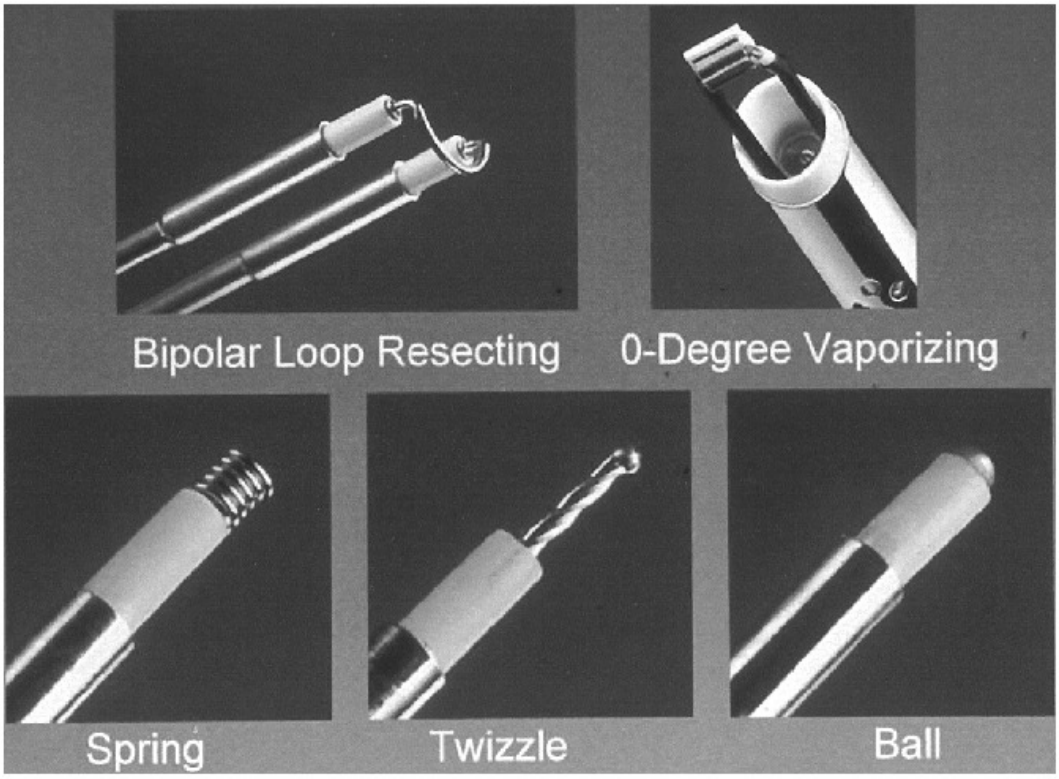
**FIGURE 15.6** **A.** Direct vision intrauterine biopsies may be performed utilizing the biopsy forceps. **B.** Crocodile-jawed forceps are ideal for grabbing and retaining devices or tissue within the uterine cavity. **C.** Scissors have a variety of intrauterine applications, including cutting adhesions and uterine septa. **D.** Tenaculum allows a puncturing grasp that is more secure than that of the crocodile-jawed forceps.

A variety of monopolar and bipolar electrodes are available for operative hysteroscopy. Monopolar balls, needles, shaving loops (3 mm), and ridged (vaporizing) loops can be inserted through the operating channel. Other available options include bipolar needles for myolysis, as well as bipolar ball and cutting loop electrodes, bipolar scissors, and needles. An advantage of the hysteroscopic sheath (vs. resectoscopic sheath) is that the surgeon can insert an aspirating cannula (2.3 or 3 mm) to selectively clear the field of bubbles and debris that cannot be removed by the way of the return second sheath.

A complete bipolar system marketed under the trade name of Versapoint II Electrosurgery System (Olympus America, Center Valley, PA) permits cutting and ablation via operative hysteroscope or via dedicated bipolar resectoscope. The mechanism for the bipolar current flow through the electrode, as well as commonly used instruments, is shown in **FIGURE 15.7**. The electrodes measure 5-F diameter (ie, 2 mm) and, therefore, can be accommodated by standard and isolated hysteroscopic channels. The biggest advantage of this bipolar technology is that saline may be used as the distension media for the operative hysteroscopy, reducing the risk of hyponatremia associated with nonionic fluids (see sections on Media and Complications).


Saline
Environment
Return
Electrode
Vapor Pocket
Active Electrode
Controlled
Thermal
Effect
Current Flow

A



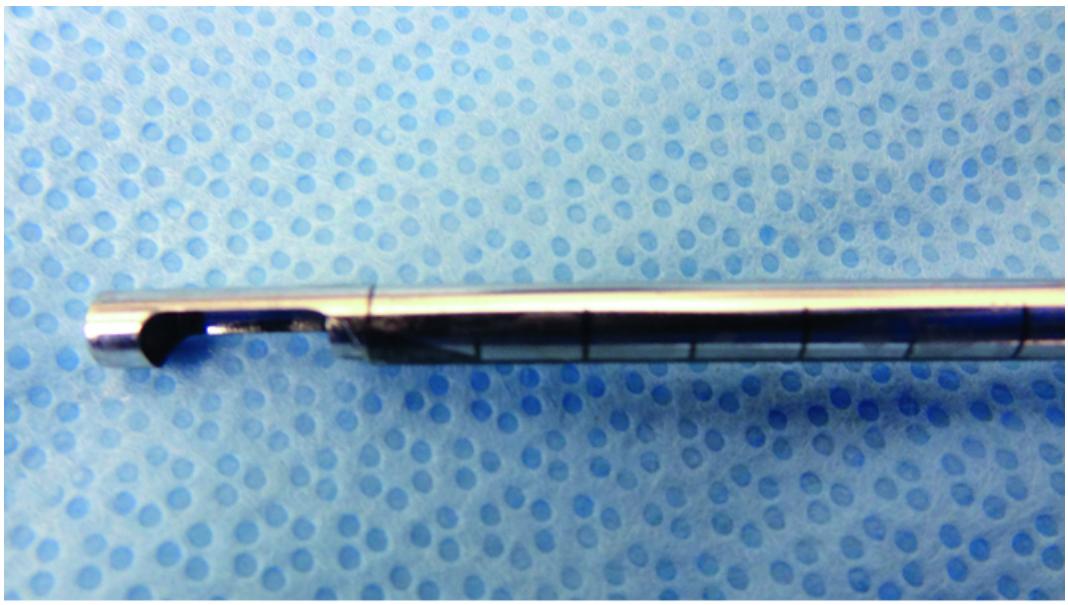

B

**FIGURE 15.7** **A.** The mechanism of action for a bipolar electrode is illustrated. The coiled bottom portion is the active electrode, and the upper (separately illustrated) metal portion serves as the return electrode. The saline medium facilitates the conduction of current between the two poles (© Ethicon, Inc. 2019. Reproduced with permission). **B.** Several bipolar electrodes are shown. The major advantage of bipolar devices is the ability to use normal saline as the distending fluid medium.

Hysteroscopic morcellators are an alternative to the resectoscope for operative excisional cases such as removing uterine submucosal myomas. Two such systems are TruClear hysteroscopic morcellator (Smith & Nephew, Andover, MA) and the MyoSure tissue removal system (Hologic, Bedford, MA) (**FIGS. 15.8** and 21.8). Both systems use suction-based, mechanical energy, rotating tubular cutter systems (rather than the high-frequency electrical energy used by resectoscopes). The benefits of these systems include the ability to use isotonic distension media such as normal saline and an improved visual field, as resected “fibroid chips” are removed.

**A**

B



C

**FIGURE 15.8** **A.** Hysteroscopic morcellator setup. Note the angled telescopic portion, which allows the camera to be attached. Disposable device is inserted down an operative channel. **B.** Hysteroscopic morcellator setup by MyoSure. Shown at the

top of the panel is the angled telescope with an operative channel and media inflow port. The outer sheath (*second from top*) includes an articulated obturator that allows for a blind entry if preferred by the surgeon. The motor attaches to suction and the below disposable morcellating piece. **C.** The working/cutting end of the morcellator. Note the blunt end with a protected rotating blade located inside the curvature, which oscillates cutting tissue and pulling cut portions inside the lumen of the instrument for removal. Cutting can only occur along the lateral open edge. (**A-C.** Courtesy of HOLOGIC, Inc. and affiliates.)

## The Flexible Hysteroscope

Fiberoptic hysteroscopes offer the benefit of an outer diameter of 3.8 mm, or even less, allowing easy access into the uterine cavity. The ability to curve allows it to easily traverse the cervical canal without dilation, making it well tolerated by the patient during office hysteroscopy with no anesthesia. A flexible fiberoptic hysteroscope consists of three sections: a soft flexible front section, a rigid rotating middle section, and a semirigid rear section. Several manufacturers produce fiberoptic flexible hysteroscopes (**FIG. 15.9**). Contemporary fiberoptic hysteroscopes are available with single-use, sterile sheaths that eliminate the need to sterilize equipment between cases.

**FIGURE 15.9** Flexible fiberoptic hysteroscopes can be manipulated to turn at virtually any angle.

## DISTENSION MEDIA AND FLUID MANAGEMENT

Under normal circumstances, the uterine cavity is a potential space, with the anterior and posterior walls in close apposition. To achieve a panoramic view within the uterus, the walls must be separated. Due to the thick muscle of the uterine wall, a minimum pressure of 40-70 mm Hg is required to distend the cavity sufficiently for visualization. Pressures approximating 70 mm Hg also propels the medium through the fallopian tubes into the peritoneal cavity. An intrauterine pressure of 125-150 mm Hg may be required to optimize visualization if there is uterine bleeding. Overdilation of the cervix with a loosely applied hysteroscopic sheath results in media leakage,

suboptimal pressure, and poor expansion of the uterine cavity. In contrast, tight application of the sheath maintains the medium within the cavity, maintaining intrauterine pressure above mean arterial pressure and a clear operative field.

There are several choices for distension media. The ideal distension media is nontoxic, hypoallergenic, and rapidly cleared while allowing clear visualization. Choice of a distension medium depends on whether diagnostic or operative hysteroscopy is planned and on the specific instrumentation utilized. Media can be conveniently divided into liquid or gas. Liquid media may be further subdivided into low-viscosity and high-viscosity fluids, with low-viscosity fluids categorized by electrolyte content. **TABLE 15.1** provides an overview of distension media available for hysteroscopy. Liquid distension media should be warmed to room temperature prior to use to avoid hypothermia.

## TABLE 15.1
## Overview of Types of Distension Media

| MEDIA | CHARACTERISTICS | HYSTEROSCOPIC USES | POTENTIAL RISKS | SAFETY PRECAUTIONS/COMMENTS |
|---|---|---|---|---|
| **Low Viscosity, Electrolyte Rich** | | | | |
| Normal saline | 0.9% saline<br>Isotonic<br>308 mOsm/L | Diagnostic<br>Operative<br>Bipolar electrocautery | Fluid overload | End procedure with fluid deficit of 2500 mL |
| Lactated Ringers | Water, sodium chloride, potassium, calcium<br>Isotonic<br>273 mOsm/L | Diagnostic<br>Operative<br>Bipolar electrocautery | Fluid overload | |
| **Low Viscosity, Electrolyte Poor** | | | | |
| Mannitol 5% | 6-carbon sugar<br>Iso-osmolar<br>285 mOsm/L | Operative<br>Monopolar electrocautery | Fluid overload<br>Hyponatremia | Stop procedure with fluid deficit of 1000 mL<br>For elderly or medically complicated patients, stop procedure with fluid deficit of 750 mL |
| Sorbitol 3% | Reduced form of dextrose<br>Hypo-osmolar<br>178 mOsm/L | Operative<br>Monopolar electrocautery | Fluid overload<br>Hyponatremia<br>Hyperglycemia | |
| Glycine 1.5% | Amino acid<br>Metabolized into serine and ammonia<br>Hypo-osmolar<br>200 mOsm/L | Operative<br>Monopolar electrocautery | Fluid overload<br>Hyponatremia<br>Hyperammonemia | |
| **High Viscosity, Electrolyte Poor** | | | | |
| 32% Dextran 70 (Hyskon) | 32% dextran 70 in 10% glucose<br>Hypertonic | Diagnostic<br>Operative | Fluid overload<br>Anaphylaxis<br>Bleeding diathesis | Rarely used today<br>Can damage equipment |
| **Gaseous** | | | | |
| Carbon dioxide | Colorless gas | Diagnostic only | Gas embolism<br>Shoulder pain | Always use a hysteroscopic insufflator and NOT laparoscopic<br>Maintain inflow at <100 mL/min<br>Maintain uterine pressure at <100 mm Hg<br>Avoid Trendelenburg |

Because the pressure gradient to maintain uterine distension is 60-70 mm Hg and because subendometrial venous pressure is 4 mm Hg, hysteroscopy fluid will inevitably diffuse into the venous circulation during the procedure. Complications may result from excessive fluid absorption; therefore, the surgical team must carefully monitor the difference between the instilled and returned fluid volume. To facilitate the accurate measurement of fluid return during the procedure, the optimal surgical drape includes a urologic pouch (tucked under the buttocks) with a plastic reservoir pocket. Outflow fluid is collected in the pocket to quantify outflow, thereby allowing accurate calculation of the fluid deficit. The surgeon and anesthesiologist must communicate because intravenous fluids infused by the anesthesia team will further increase circulatory volume. Saline and other low-viscosity distension media (see below) can be delivered by hanging a 2- to 3-L bag or bottle of fluid 6-8 ft

above the operating table, permitting the fluid to infuse by gravity feed. An alternative is rotary pump. Many pumps weigh the fluid in real time and provide the surgeon a constant readout of flow rate and total volume of fluid infused. Use of an automated fluid pump and monitoring system that provides a real-time fluid deficit is recommended by both the American College of Obstetricians and Gynecologists (ACOG) and the American Association of Gynecologic Laparoscopists (AAGL) to most accurately monitor inflow and outflow and prevent complications associated with fluid overload.

# Liquid Media

## *Low Viscosity*

Low-viscosity media are the predominant distension fluid used today. These fluids must be continuously flushed through the uterine cavity to obtain a clear view. A standard diagnostic sheath does *not* allow for flushing. Therefore, if a low-viscosity fluid is used for distension, the view may be suboptimal because blood can mix with the distending fluid, creating a colored fluid through which the operator will see the field. The safest distension media will be iso-osmolar with an electrolyte content of 300 mOsm. Additionally, the sodium content of the fluid should approximate 140 mEq/L.

### Normal Saline and Lactated Ringers Solution

Normal (physiologic) saline (0.9% sodium chloride) is perhaps the safest hysteroscopic media. Complications of excessive vascular absorption can include fluid overload and pulmonary edema, which are managed by diuresis and supportive care. Because saline is an efficient conductor of electrons, it does not permit a sufficient current density for tissue action when using a monopolar system and, therefore, saline is not suitable for monopolar electrosurgery. However, saline is effective for use with a bipolar electrode, laser, or mechanical device (such as scissors). During the procedure, a nurse or surgical assistant should provide the surgeon with a running account of as the fluid deficit (the liters of fluid hung minus volume of

return fluid). When an isotonic distension medium (such as saline) is used, the American College of Obstetricians and Gynecologists' Committee on Gynecologic Practice recommends termination of the hysteroscopic procedure if the deficit reaches 2500 mL, with planned completion at a later date. Lactated Ringers solution (a mixture of sodium chloride, sodium lactate, potassium chloride, and calcium chloride in water) possesses similar properties as normal saline and is thought to provide a similar risk profile.

## Glycine 1.5%, Sorbitol 3%, and Mannitol 5%

Glycine (1.5%) and sorbitol (3%) solutions were first used in urologic surgery. They were adopted later by gynecologists for use with monopolar electrosurgical devices such as the resectoscope. Both glycine and sorbitol are hypo-osmolar (sorbitol, 178 mOsm/L; glycine, 200 mOsm/L) and, therefore, excessive vascular absorption can lead to an acute hyponatremic, hypo-osmolar state. When hypo-osmolar media are used for hysteroscopy, the ACOG recommends termination of the procedure if the fluid deficit reaches 1000 mL. If the patient is elderly or has comorbid medical conditions, the procedure should be terminated with a deficit of 750 mL. Hyponatremia is of concern because this condition produces a gradient between the circulating blood and the brain cells. The brain cells respond by pumping cation out to diminish the positive infusion of water into the brain. Unfortunately, this cation-pumping mechanism is decreased in women, likely due to progesterone, and women are, therefore, at greater risk for developing life-threatening cerebral edema during a hypo-osmolar state. An additional unique risk of glycine is that it can be metabolized to ammonia and cause neurologic damage.

Mannitol (5%) may be used with electrosurgical devices and is approximately iso-osmolar. Mannitol has an osmolality of 285 mOsm and is an osmotic diuretic. Its optical characteristics are equivalent to glycine and sorbitol; however, mannitol is less likely to cause hyponatremia due to its diuretic characteristics.

# *High Viscosity*

High viscosity fluids, such as 32% dextran 70 in dextrose (Hyskon), are no longer used for hysteroscopy due to a high risk of complications. Hyskon increases the risk of fluid overload during hysteroscopy. In addition, Hyskon is potentially associated with two severe complications: an anaphylactoid reaction and a bleeding diathesis. While Hyskon's immiscibility with blood provided excellent visualization, the media also caused a dried residue that could clog hysteroscopic sheath channels. Thus, this medium is primarily of historical interest.

## Gaseous Media

Carbon dioxide ($CO_2$) is a colorless gas that is highly soluble when mixed with blood. $CO_2$ is used only for diagnostic hysteroscopy. It can be used to safely distend the uterus when instilled with a proper insufflation apparatus. The hysteroscopic insufflator delivers $CO_2$ into the uterus at a flow rate measured in cubic centimeters per minute, in contrast to the laparoscopic insufflator, which allows $CO_2$ to flow in at a rate of liters per minute. The rate of flow of $CO_2$ into the uterus should never exceed 100 mL/min, and pressure should be adjusted below 100 mm Hg. The laparoscopic insufflator is both unsuitable and unsafe for hysteroscopic insufflation.

Before $CO_2$ is infused, the hysteroscopic tubing and the hysteroscope must be purged of air. Several precautions must be observed with $CO_2$ hysteroscopy. The Trendelenburg position should be avoided. Excessive $CO_2$ flow should be avoided, as bubbles appear and obscure the field. Also, $CO_2$ tends to flatten the endometrium, and this artifact can obscure pathology. When $CO_2$ is improperly instilled, emboli form and can produce severe derangements in cardiovascular physiology. Advantages of $CO_2$ as a distension medium include its clear visualization including entry evaluation of the endocervical canal. A major disadvantage of $CO_2$ is that it cannot be used for operative hysteroscopy due to risk of $CO_2$ embolism. Additionally, it has been associated with higher procedure-related pain, including shoulder pain.

# PREOPERATIVE CONSIDERATIONS

Informed consent clearly reviewing the risks, benefits, and alternatives should be obtained prior to a hysteroscopic procedure. Complications of hysteroscopy are reviewed in detail elsewhere in this chapter, but important risks to review include risk of uterine perforation, bleeding, infection, fluid overload, and, in extremely rare circumstances, injury to the bowel, bladder, vessels, or nerves. Overall, risk of uterine perforation is 1%-3%. The risk of need for repeat procedure or inability to perform the procedure should also be reviewed. Contraindications to performing hysteroscopy include acute pelvic or vaginal infection, pregnancy, and recent uterine perforation. Known cervical or uterine cancer is a relative contraindication; in such cases, hysteroscopy can sometimes be used (typically by a gynecologic oncologist) for diagnostic purposes. Active bleeding is a relative contraindication as bleeding may limit visualization. To optimize visualization and decrease risk of performing hysteroscopy during an early pregnancy, hysteroscopy is best performed in the early follicular phase shortly after menses have stopped (optimally days 6-10 of the cycle). If it is difficult to schedule hysteroscopy, particularly operative hysteroscopy, during the early follicular phase, another option is to treat the patient with oral contraceptive pills to ensure a thin uterine lining that will enhance visualization.

Traversing the cervical canal is a key aspect of hysteroscopic surgery. For some patients, cervical stenosis may increase the risk of complications such as creation of a false passage or uterine perforation. Anticipation of cervical stenosis may allow preoperative interventions to reduce these risks. Misoprostol, a synthetic prostaglandin $E_1$, has been studied extensively as a cervical dilator prior to hysteroscopy to prevent complications associated with dilatation. Although the optimal dose and mode of administration (oral vs vaginal) have yet to be determined, a commonly used dose is 200-400 mg misoprostol administered vaginally 12-18 hours prior to the procedure. (Oral administration is also an option.) A 2015 Cochrane systematic review and meta-analysis included 19 trials evaluating cervical ripening with misoprostol prior to operative

hysteroscopy. The group reported that both premenopausal and postmenopausal patients treated with misoprostol were less likely (vs placebo) to require additional mechanical dilation and experienced fewer complications, including false track formation. Side effects of misoprostol include mild abdominal pain and cramping, vaginal bleeding, and increased body temperature. For postmenopausal patients, the beneficial effects of misoprostol prior to hysteroscopy can be augmented by estrogen pretreatment of 25-mg estradiol tablets vaginally for a minimum of 2 weeks prior to the procedure. Osmotic dilators such as laminaria are also option for patients with contraindications to prostaglandins. A drawback is that the patient requires an office visit prior to the procedure for insertion.

In addition to misoprostol, dilute vasopressin (4 units of 0.05 unit/mL vasopressin in 80 mL of normal saline) injected unto the cervical stroma at 4- and 8-o'clock positions (20 mL total volume injected) may be of benefit. Phillips et al. (1997) demonstrated that the above vasopressin pretreatment for hysteroscopy significantly reduced the force needed to dilate the cervix. Additionally, transabdominal ultrasound should be available when a difficult cervical entry is anticipated. Performed with a fluid-filled bladder, transabdominal ultrasound can provide visualization of a path that can be continuously monitored as mechanical dilators are advanced.

# OFFICE HYSTEROSCOPY

While it's estimated that ~25% of U.S. gynecologists currently perform office hysteroscopy, this percentage has been increasing due to technological advancements, patient convenience, and improved reimbursement. Hysteroscopic procedures that can be performed in the office range from the simple (such as diagnostic hysteroscopy, endometrial biopsy with direct visualization, polypectomy, and removal of dislodged intrauterine devices [IUDs]) to more involved procedures (such as resection of small myomas, septum excision, and tubal sterilization). When planning office hysteroscopy, patient selection is key. Patients with anticipated cervical stenosis or inability to tolerate the procedure should not be

offered office hysteroscopy. Short, simple procedures 30 minutes or less should be selected.

For diagnostic hysteroscopy, small-diameter single-channel scopes are typically used. These include flexible fiberoptic hysteroscopes and digital hysteroscopes such as the Endosee (CooperSurgical Inc., Trumbull, CT). Flexible hysteroscopes are 3.2-3.5 mm in diameter with a tip that deflects over a range of 90°-120°, not requiring cervical dilation. For operative hysteroscopy, a single-flow rigid hysteroscope with a 4- to 5-mm outer sheath can be used in the office with semirigid instruments such as scissors, graspers, and biopsy forceps. Endosee Advance also has a working channel that allows for simple operative hysteroscopic in the office such as lysis of intrauterine adhesions, polypectomy, and removal of IUDs. In addition to standard hysteroscopic techniques, a vaginoscopic approach to hysteroscopy has also been described without the use of a speculum or tenaculum to grasp the cervix. In this approach, the hysteroscope is inserted into the vagina, which is distended with distension media. The external cervical os is entered with the scope and the cervical canal is traversed to enter the cavity. Cooper et al. (2010) in a systematic review reported that this technique is associated with significantly less pain and discomfort than traditional hysteroscopic entry into the cervical canal.

Regarding analgesia, patients typically experience minimal discomfort during and after office hysteroscopy. A meta-analysis of 15 hysteroscopy trials found no benefit of pretreatment with opiates or anxiolytics. Two small studies also demonstrated that pretreatment with oral tramadol 50-100 mg 1 hour prior to the procedure can decrease pain and discomfort during office hysteroscopy. Although the study found no benefit to pretreatment with nonsteroidal anti-inflammatory drugs, patients are often advised to take 400-600 mg of ibuprofen (or the equivalent) ~1 hour before the procedure. A paracervical block has been shown to decrease pain associated with hysteroscopy. The injection of lidocaine 1%, 10-15 mL, directly into the cervix produces adequate anesthesia.

The gynecologic surgeon should first master hysteroscopic procedures in the operating room with patients under anesthesia (with diagnostic cases followed by simple operative cases) prior to

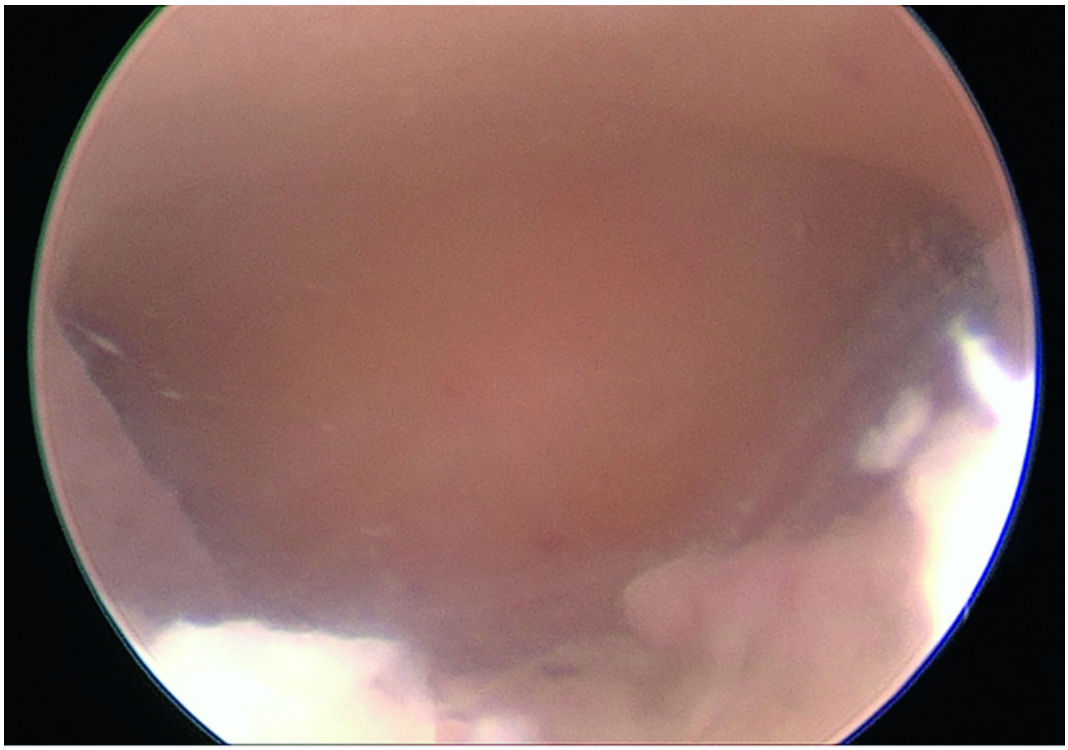
offering office hysteroscopy. The essential steps to performing the procedures are similar whether in the office or operating room.

# DIAGNOSTIC HYSTEROSCOPY

Diagnostic hysteroscopy can be performed in an office setting under local anesthesia or in the operating room. The latter may be preferred if an operative procedure that cannot be easily performed in the office is anticipated. Accurate knowledge of the position of the uterus is critical to safely facilitate the procedure. After placing the patient in the dorsal lithotomy position, the perineum and vagina are gently swabbed with Betadine or another suitable antiseptic solution. A Sims retractor or breakaway speculum is inserted to allow visualization of the cervix. The cervix is grasped at the 12 o'clock position with a single-toothed tenaculum. In some circumstances, it may not be necessary to use a tenaculum, depending on the uterine orientation and the diameter of hysteroscope used. A suitable telescope is selected and checked by the operator for clarity of the eyepiece and objective lens. If necessary, the lens is cleansed with a soft saline-soaked or water-soaked sponge. The light generator is switched on, and the fiberoptic cable is attached to the telescope. The telescope is inserted into the diagnostic sheath, and the selected medium is flushed through the sheath to expel any air within the sheath.

For diagnostic hysteroscopy, routine dilatation of the cervix should be initially avoided, because even gentle insertion of cervical dilators can traumatize the endocervix and endometrium as well as increase patient discomfort. If the hysteroscope is inserted into the canal under direct vision, and if the axis of the cervical and uterine canal is carefully followed until the corpus is reached, there should be no risk of creating a false passage or perforation. Typically, the endocervical canal shows longitudinal folds, papillae, and clefts. The internal os appears as a narrow constriction at the top of the endocervical canal. The isthmus is a cylindrical extension above the os, and the corpus is a capacious cavity above the isthmus. **FIGURE 15.10A** shows a normal uterine cavity by hysteroscopy. The tubal ostia are visible at the upper extremities of the fundal cornua and

show great variation in appearance and angle of entry into the uterine cavity. The endometrium is smooth and pink-white in color during the proliferative phase. The gland openings appear as white-ringed elevations surrounded with netlike vessels. As noted, hysteroscopy should be performed during the follicular phase of the menstrual cycle, if possible, or while the patient is on oral contraceptive pills. During the secretory phase of the cycle, the endometrium is lush and velvety; it protrudes into the cavity irregularly and can be easily mistaken for small polyps. Although the cornua are easily recognized, the tubal ostia may not be seen during the latter phase of the menstrual cycle (**BOX 15.1**).



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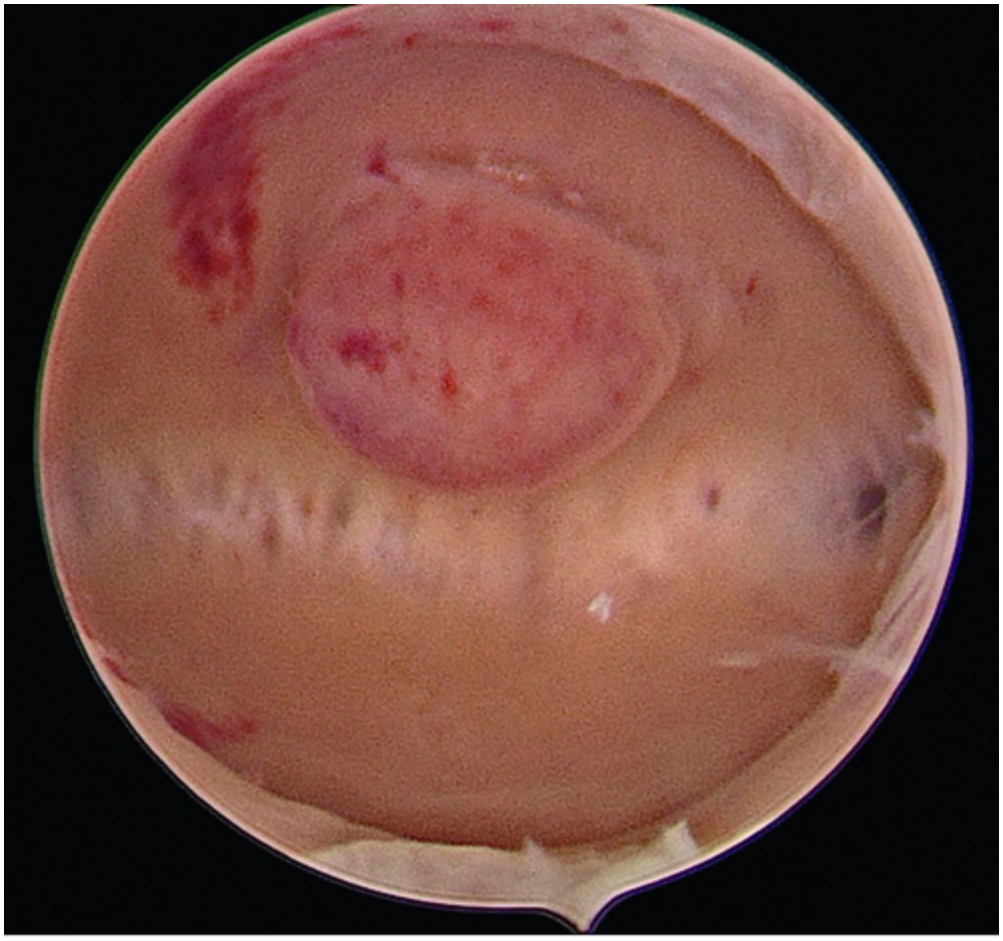


B

**FIGURE 15.10** **A.** Normal-appearing uterine cavities on diagnostic hysteroscopy. **B.** A uterine polyp at the uterine fundus.

## BOX 15.1 STEPS IN THE PROCEDURE

### Diagnostic Hysteroscopy

- Lithotomy position, bimanual examination: uterus anteverted or retroverted.
- Empty the bladder; drape the perineum into sterile fluid.
- Position fluid collection bag under buttocks.

- Verify correct hysteroscopic equipment and distension media.
- The cervix is visualized with bivalve speculum or Sims retractor.
- Tenaculum is applied to the anterior lip of the cervix.
- Dilation of cervix, if required (dilatation not required for diagnostic scope); do not overdilate.
- Place hysteroscope in the external os, with distension media flowing; insert under direct visualization; countertraction is applied using the tenaculum.
- Inspect the endocervical canal during entry of hysteroscope.
- Once inside the uterine cavity, remove the speculum or Sims retractor with hysteroscope in place.
- Verify/orient position by identifying tubal ostia.
- Inspection should include the cervical canal, panoramic view of the cavity, bilateral tubal ostia, and anterior and posterior uterine walls.

# OPERATIVE HYSTEROSCOPY

The telescope is inserted into the operative or resectoscope sheath. If the operative sheath is used, a proper nipple is selected and attached to the operating channel opening. The sheath is flushed with distension media, and the light cable is attached.

In some cases, dilatation may not be necessary, particularly when using a hysteroscope with a smaller diameter sheath. Otherwise, careful dilatation with Pratt dilators should be performed until the operative sheath negotiates a tight passage through the cervix. With the medium flowing, the hysteroscope can be inserted into the uterine cavity under visualization. The uterine cavity is scanned, and the operator identifies landmarks (eg, the tubal ostia, depth of the cornua, the location and attachments of the lesion, the proximity of the internal cervical os). If there is difficulty viewing the cavity clearly, the hysteroscope has probably been inserted too

deeply, and the telescope has come in contact with the uterine wall. When the view is blocked, the most prudent first maneuver is to pull the instrument back with the medium flowing into the uterus.

After a clear view is obtained, the operating device (eg, electrode or scissors) is inserted into the cavity and advanced to make contact with the target tissue. With a constant flow sheath, the cavity can be further distended by closing off the return valve stopcock. The valve is then opened, and the cavity is flushed clear. In certain complicated cases, the surgeon may choose to perform simultaneous laparoscopy to permit an assistant to view the serosal surface of the uterus to provide some additional insurance against inadvertent perforation. Clinical scenarios in which simultaneous laparoscopy or ultrasound guidance may be beneficial include excision of a septum, lysis of uterine adhesions, and excision of large submucosal myomas (**BOX 15.2**).

# BOX 15.2 STEPS IN THE PROCEDURE

## Operative Hysteroscopy

- Follow initial steps for diagnostic hysteroscopy.
- If visualization is cloudy, open outflow valve to clear, and then reclose; leave slightly open for fluid circulation if necessary.
- Constantly monitor fluid deficit: halt procedure at a deficit of 750 mL (nonelectrolyte) or 2500 mL (electrolyte) depending on distension.

## Myomectomy

- *Resectoscope:* 90° loop released with continuous-wave (cutting) electrocautery at 80-100 W; progressively shave myoma with occasional removal of fibroid fragments; loop is always pulled toward hysteroscope when cutting.
- *Morcellator:* handpiece placed through operative channel with distal tip adjacent to fibroid edge. Activate cutting action with foot pedal as handpiece remains stationary.

### Polypectomy

- Insert hysteroscopic scissors and cut polyp at the base.
- Insert hysteroscopic forceps to grasp polyp and excise.
- Alternative methods: resectoscope or morcellator (similar to myomectomy).

### Septum Excision

- Identify both uterine chambers and bilateral tubal ostia.
- Using hysteroscopic scissors or other cutting device, divide the septum at midportion.
- Take care when approaching the fundus to avoid perforation or bleeding.

### Lysis of Adhesions

- Perform a thorough diagnostic hysteroscopy to identify landmarks.
- Using scissors or other cutting device, cut filmy and central adhesions first.
- Cut marginal and dense adhesions last, always cutting from below and moving upward.
- Maintain hysteroscope in midchannel relative to uterine walls.

## Electrosurgical Devices and Lasers

Electrosurgical devices and lasers both exert their tissue actions in a similar fashion. They both produce coagulation at 60 °C-70 °C and vaporization at 100 °C. Similar tissue actions can be produced by raising the power density or by keeping the power constant and increasing the tissue exposure time. A 1-mm laser fiber delivering 30 watts (W) of power to tissue will create a power density of 3000 $W/cm^2$. A 3-mm ball electrode will need to generate 300 W of power to create a similar power density. The Nd:YAG laser, which works by

thermal energy, is the preferred laser for hysteroscopic surgery. The Nd:YAG laser beam can be transmitted equally well with any distension media, whereas monopolar electrosurgical devices operate most effectively in an electrolyte-free medium.

Regardless of whether the surgeon uses a resectoscope, handheld electrode, or laser, depth of tissue action is extremely important. Transmural injury is possible at high-power densities or with prolonged exposure. The surgeon must be familiar with the physics governing the actions of electrosurgical tools and lasers and with the tissue actions exerted by these energized devices. A knowledgeable surgeon would not use a ball device to cut or a loop electrode to coagulate tissue. Proper selection of wattage depends on disease pathology and location. High power applied for a long period of time increases the probability of significant tissue injury. The surgeon must keep in mind that the thickness of the distended uterine wall (0.5-1 cm) is considerably less than that of the nondistended uterine wall (1.5-2 cm). Uterine perforation by either a laser fiber or an electrode is much more serious than perforation by scissors or another mechanical device, because the thermal energy can inflict great damage to surrounding structures (eg, bowel or bladder). The injury may not attain its maximum damage until 2 or 3 days after surgery. Therefore, either laparoscopy or laparotomy is indicated in such cases to determine the extent of injury.

# SPECIFIC PROCEDURES IN HYSTEROSCOPIC SURGERY

## Hysteroscopic Myomectomy

Submucosal myomas characteristically appear as white spherical masses covered with a network of fragile thin-walled vessels when viewed by hysteroscopy. Preoperatively, imaging such as saline infusion sonohysterogram or pelvic MRI is recommended. Myomas typically are sessile or pedunculated. The European Society for Gynaecological Endoscopy categorizes submucosal myomas as type 0, 1, or 2. Type 0 myomas are 100% located within the uterine

cavity, while type 1 fibroids have an intramural component of <50% and type 2 submucosal myomas have an intramural component that comprises more than 50%. In general, type 0 and type 1 myomas are candidates for resection, while type 2 myomas may be best excised by laparoscopic or open technique.

## *Hysteroscopic Technique*

Several variations of hysteroscopic procedures are available to excise submucosal myomas. A resectoscope is commonly used today, typically employing monopolar cautery and nonelectrolyte distension media; bipolar resectoscopes can be used with electrolyte media. To excise a myoma, the 90° loop electrode is typically used with continuous-wave (cutting) electrocautery at 80-100 W. Under video control, the resectoscopic technique consists of progressively shaving the myoma and removing pieces of tissue for subsequent histologic evaluation. For fundal myomas, the straight electrode is the most effective device, whereas the angulated electrode is preferred for lesions located on the anterior or posterior walls (**FIG. 15.11**). The electrode should be activated only while returning toward the hysteroscope, never while advancing outward away from the lens. The greatest disadvantage to this technique centers on the need to repeatedly remove the shaved fragments of tissue.

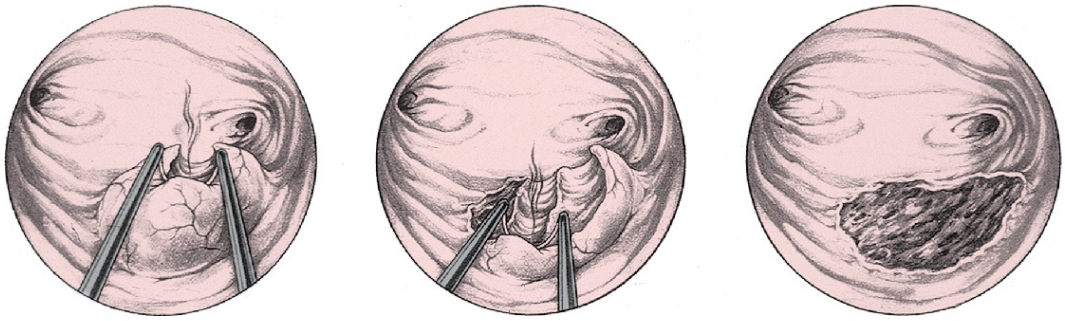


**FIGURE 15.11** The shaving technique for the elimination of a submucosal myoma is shown using an angulated loop electrode via the resectoscope. (From Baggish MS, Barbot J,

Valle RF. *Diagnostic and Operative Hysteroscopy*. 2nd ed. Mosby-Year Book; 1999. Reprinted with permission from Michael S. Baggish, MD.)

Other electrosurgical techniques may be employed in conjunction with the large isolated channel, flushing hysteroscope. Three-millimeter needles, shaving loops, and bipolar electrodes may be used to perform all of the optional operations described above for the resectoscope. The 3-mm retractable cutting loop can perform shaving procedures in a fashion similar to that of the resectoscope loop. Bipolar needles can be plunged many times into the substance of the submucosal myoma of any size to coagulate the interior of the myoma (myolysis).

Hysteroscopic morcellators are now frequently used to excise submucosal myomas. With these devices, a handpiece is placed through the operative channel of the operative hysteroscope with the distal tip adjacent to the edge of the fibroid. Cutting action is activated by a foot pedal as the handpiece remains stationary. The myoma is morcellated until the fibroid bed is flush to adjacent myometrium and fragments of the fibroid are suctioned during the case. The advantage of hysteroscopic morcellation of uterine fibroids is that it is faster than using a resectoscope with no fibroid fragment floating in the operative field during the case.

When large myomas (3-5 cm) are resected and extracted, it may be prudent to do a simultaneous laparoscopy or perform under ultrasound guidance if there is concern for risk of uterine perforation. A central fundal myoma is associated with the greatest risk of uterine perforation. Regarding risk of malignancy from submucosal fibroids, the risk of leiomyosarcoma is <1%. Nevertheless, any myoma (or part of a myoma) that is excised should be sent for pathologic evaluation.

## Uterine Polyps

Functional and nonfunctional polyps are a common cause of abnormal uterine bleeding (see **FIG. 15.10 B**). Functional polyps tend to be smaller than nonfunctional polyps. A functioning polyp has a surface identical to the surrounding endometrium. The nonfunctioning polyp presents as a white protuberance covered with branching surface vessels. Polyps are relatively easy to diagnose by saline infusion sonohysterogram or hysterosalpingogram. Hysteroscopy is superior to blind techniques for surgical removal. Gebauer et al. compared blind removal of uterine polyps (curettage and polyp forceps) with hysteroscopy. While polyps were diagnosed in 43% of cases by curettage, 68% of attempted polyp removal with a polyp forceps demonstrated residual polyp.

## *Hysteroscopic Technique*

There are several hysteroscopic techniques to excise uterine polyps. One common utilized method involves cutting the polyp at its base with hysteroscopic scissors followed by grasping the polyp with alligator jaw forceps. This can be performed with either a dual-channel or single-channel operating hysteroscope. The hysteroscope is withdrawn, removing with it the freed polyp, which is sent to the pathology laboratory for histologic evaluation. The site of removal is inspected again and the procedure terminated. In another method, the polyp can be simply grasped with hysteroscopic polyp forceps and removed with a twisting motion (**FIG. 15.12**). If any bleeding is observed, a 3-mm ball electrode is applied to the site for coagulation (40-50 W). Alternatively, a polyp may be cut at its base with a retractable electric snare loop, needle electrode, or laser fiber. The polyp may also be shaved by means of the resectoscope or a hysteroscopic morcellator similar to a myoma.

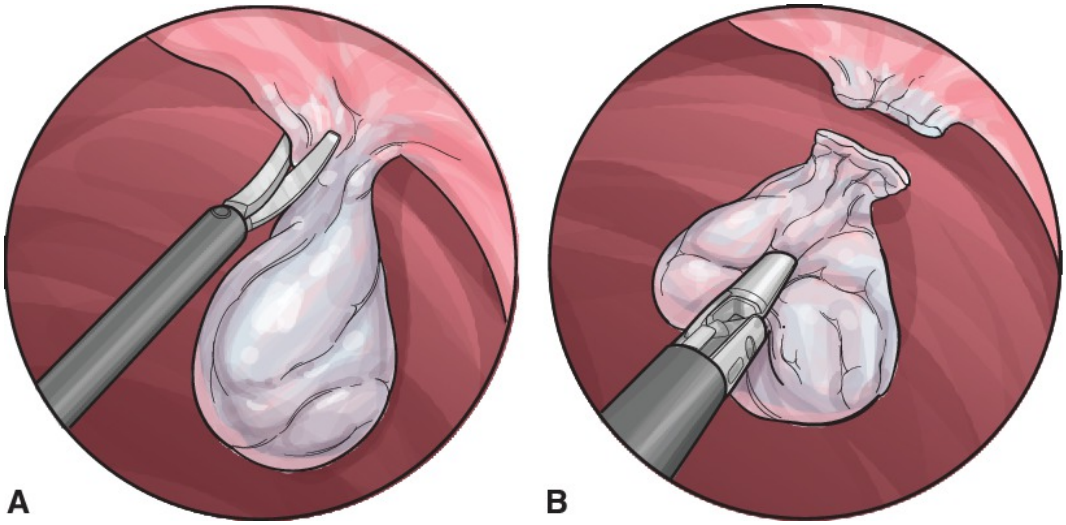



**FIGURE 15.12** **A.** Single- or dual-channel hysteroscope used to resect a polyp by cutting polyp at its base with scissors and then grasping with forceps. **B.** Forceps used to grasp and excise the polyp.

## Septate Uterus

Uterine septa may contribute to pregnancy loss usually secondary to spontaneous abortion. Almost all septa can be treated hysteroscopically. Diagnosis is typically by hysterosalpingogram or 3D saline infusion sonohysterogram, both of which show uterine filling defects. Pelvic MRI can also be used to confirm the diagnosis. The standard technique, first reported in 1978 by March and colleagues, is to cut the septum with scissors under direct hysteroscopic view.

### *Hysteroscopic Technique*

The uterine septum is viewed from the level of the internal cervical os (**FIG. 15.13**). The endoscope is moved into each chamber of the divided uterine cavity with the specific location of tubal ostia noted. The hysteroscope is then withdrawn to a level just above the internal

os. The appropriate operating instrument is inserted through the sheath, usually a pair of scissors, and the septum is divided in its midportion (**FIG. 15.14**). There is usually no need to remove tissue, as the septal tissue retracts after it is incised. In some cases, it is beneficial to perform simultaneous laparoscopy. As the fundus is approached, the operator depends on a signal from the assistant performing the laparoscopy to indicate when hysteroscope light demonstrates transmission through the intact uterine wall. An alternative technique permits the operator to scan the uterus sonographically to determine whether the myometrium has been entered and monitor the amount of space existing between the operating device and the serosal surface of the uterus. The surgeon should be aware of the common tendency of the cutting instrument to drift posteriorly and should clip the septum squarely in the middle. When the drift goes unnoticed, the operating instrument can cut into the myometrium and cause pulsatile bleeding. Similarly, correcting the septum too aggressively at the level of the fundus will result in deep penetration into the myometrium and subsequent hemorrhage. If a multichannel hysteroscope is used, a 3-mm ball electrode may be used to coagulate the bleeding vessel. The double-needle bipolar electrode is a safe alternative method for electrocoagulation. Patients are often advised to take estrogen daily following surgery, typically for 2-4 weeks (conjugated equine estrogens 2.5 mg by mouth daily or oral estradiol 4 mg daily). In challenging cases, such as a repeat septum excision due to adhesion formation, insertion of a uterine stent or Foley balloon may be beneficial.

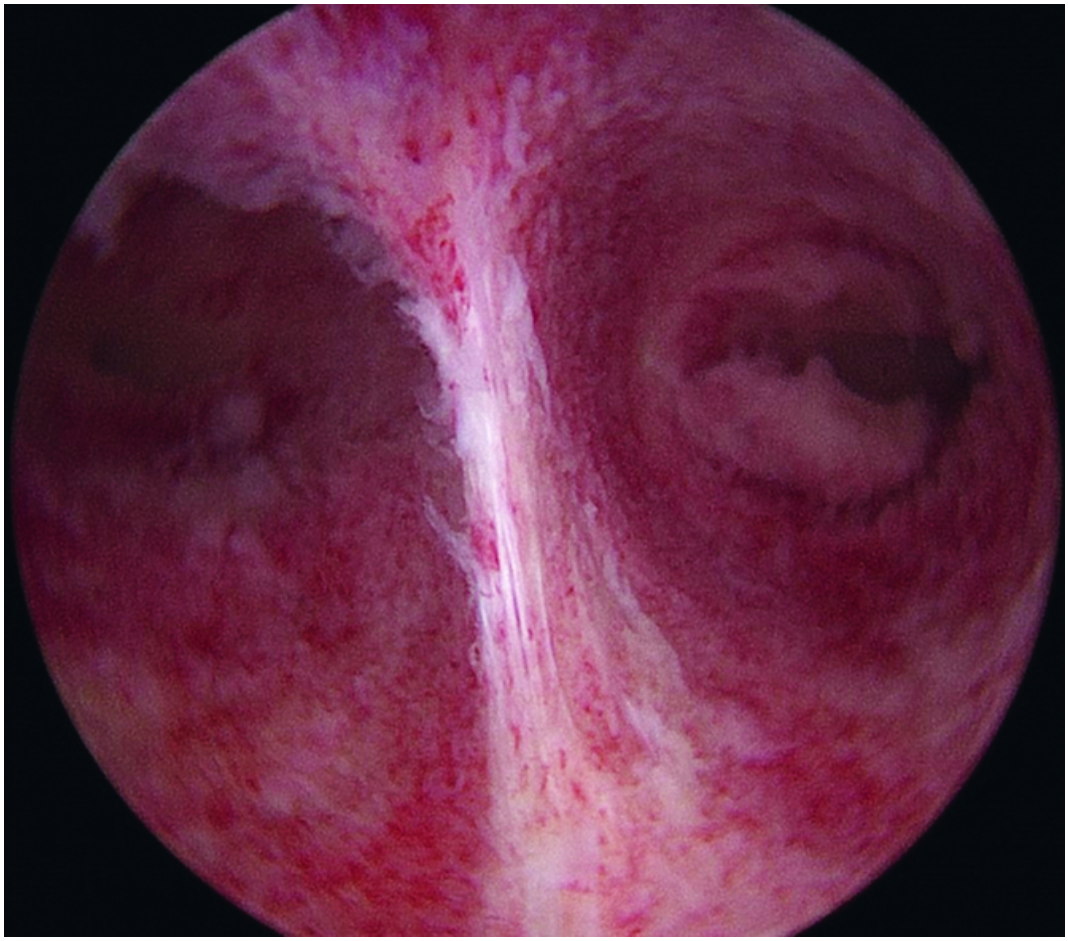


**FIGURE 15.13** Uterine septum on hysteroscopy extending over 75% into the uterine cavity. (Courtesy of Dr. Samantha Pfeifer.)

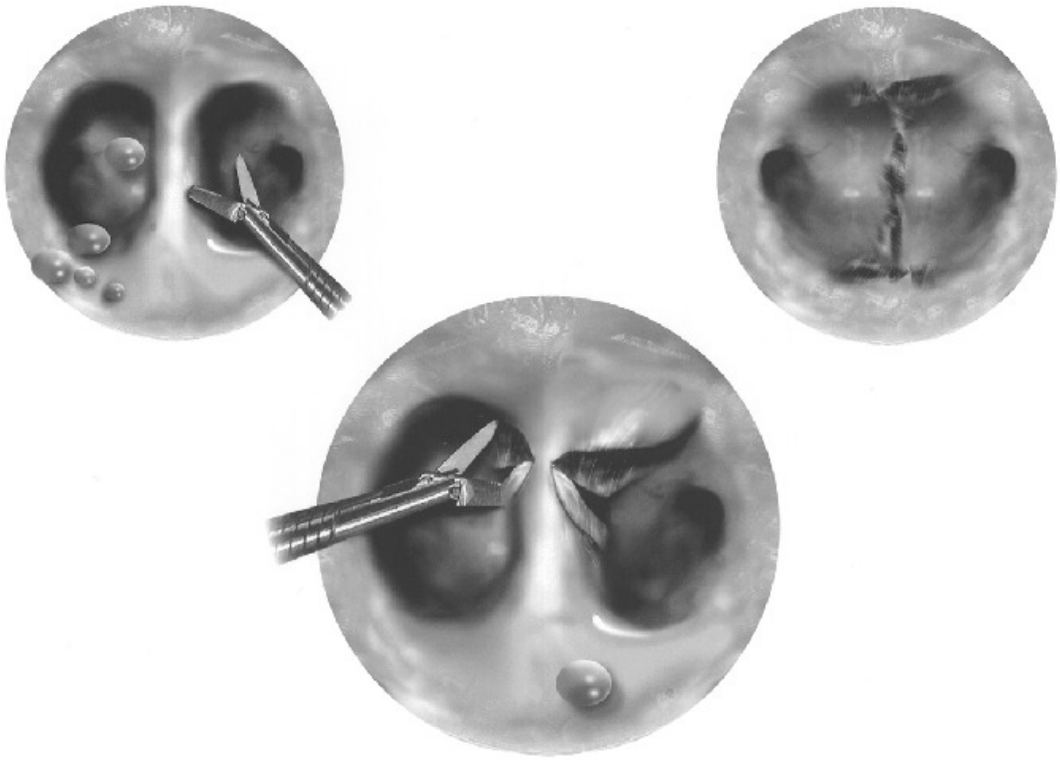
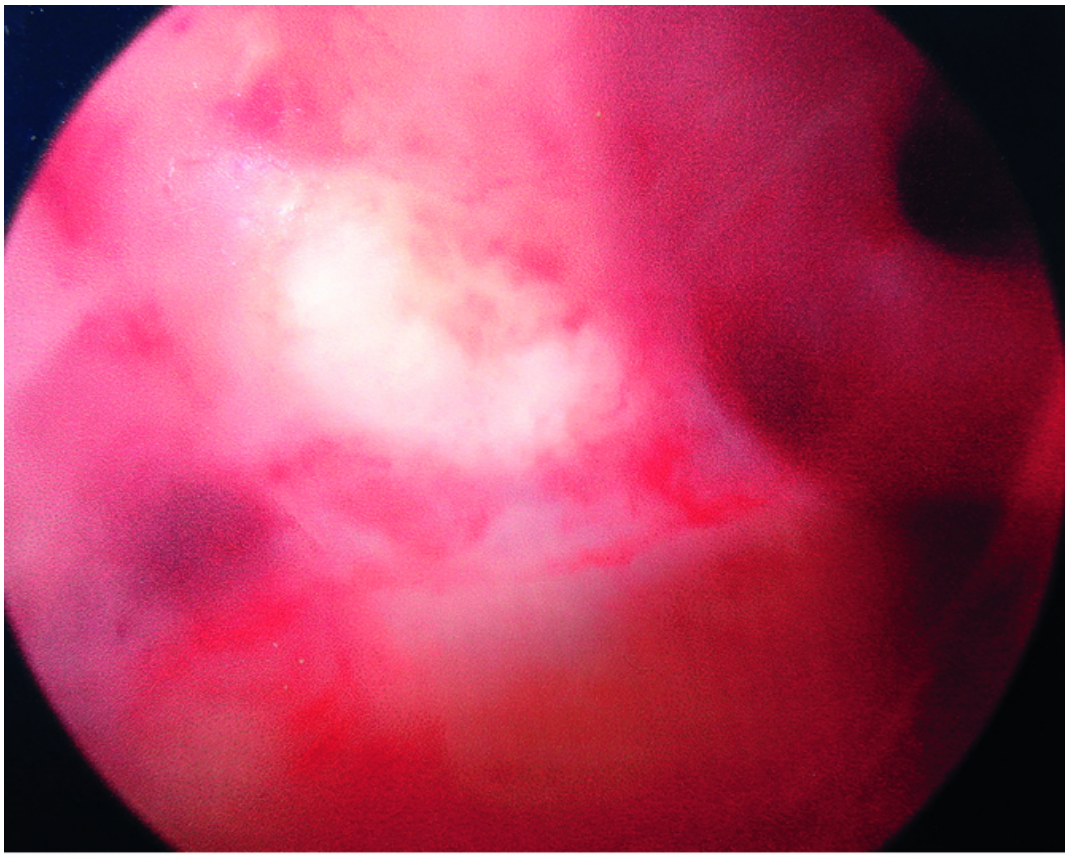


**FIGURE 15.14** **Upper left:** Hysteroscopic view of a septate uterus immediately before cutting the septum. **Center:** The septum is cut approximately at midpoint, taking care not to drift too far posteriorly. Thicker septa are cut from periphery inward to the center. **Upper right:** The septum has been completely incised. (Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

# Intrauterine Adhesions

Adhesions may form between the anterior and posterior walls of the uterus as a result of trauma or infection in a milieu of estrogen deprivation. The formation of intrauterine adhesions or synechiae is also referred to as Asherman syndrome. Risk factors for uterine synechiae include uterine infection, postpartum hemorrhage for which a vigorous curettage has been performed, as well as repetitive uterine curettage procedures. Presentation includes amenorrhea or scant flow with menses. Diagnosis is typically by hysterosalpingogram or saline infusion sonohysterogram, both of which show uterine filling defects. Previous treatment of uterine synechiae consisted of blind curettage with poor results. With the advent of operative panoramic hysteroscopy, treatment progressed to identification of adhesions and sharp incision of the adhesions with scissors (**FIG. 15.15**). Adhesiolysis surgery can be among the most challenging of hysteroscopic procedures. Because numerous vascular channels are opened, the risk of intravascular absorption of the medium is high.



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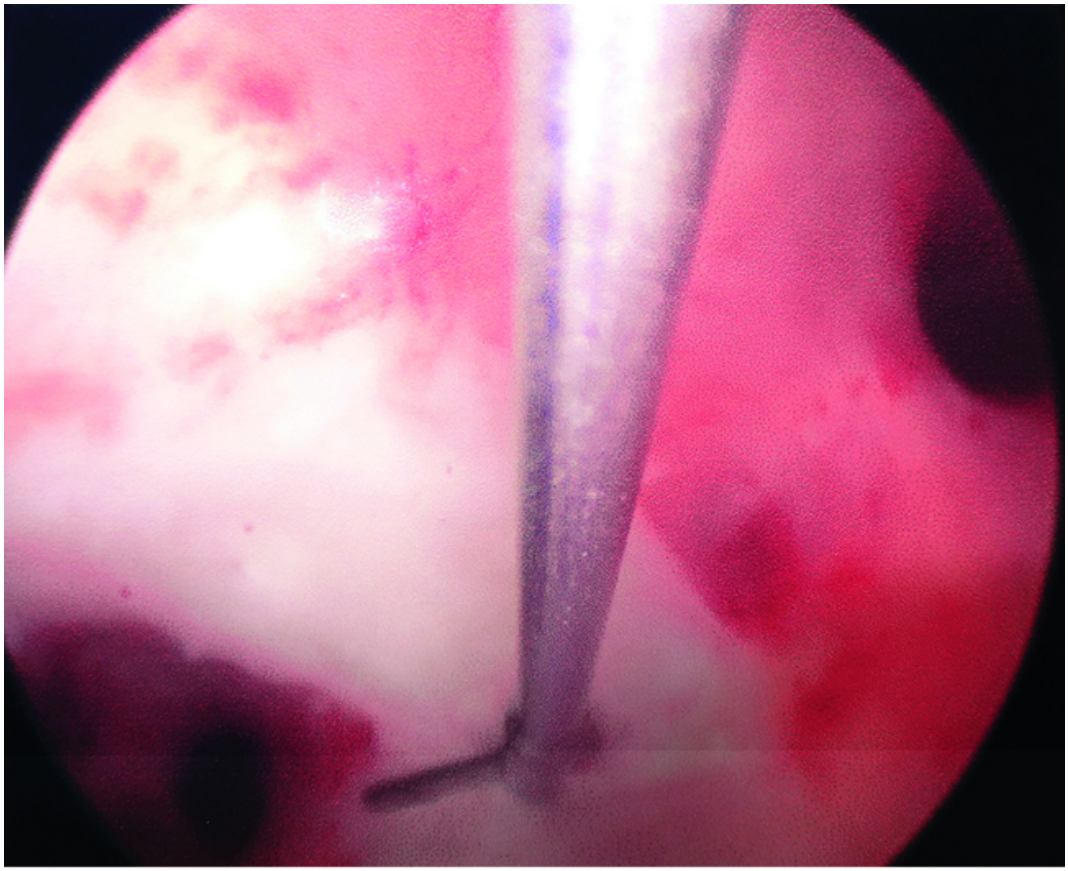

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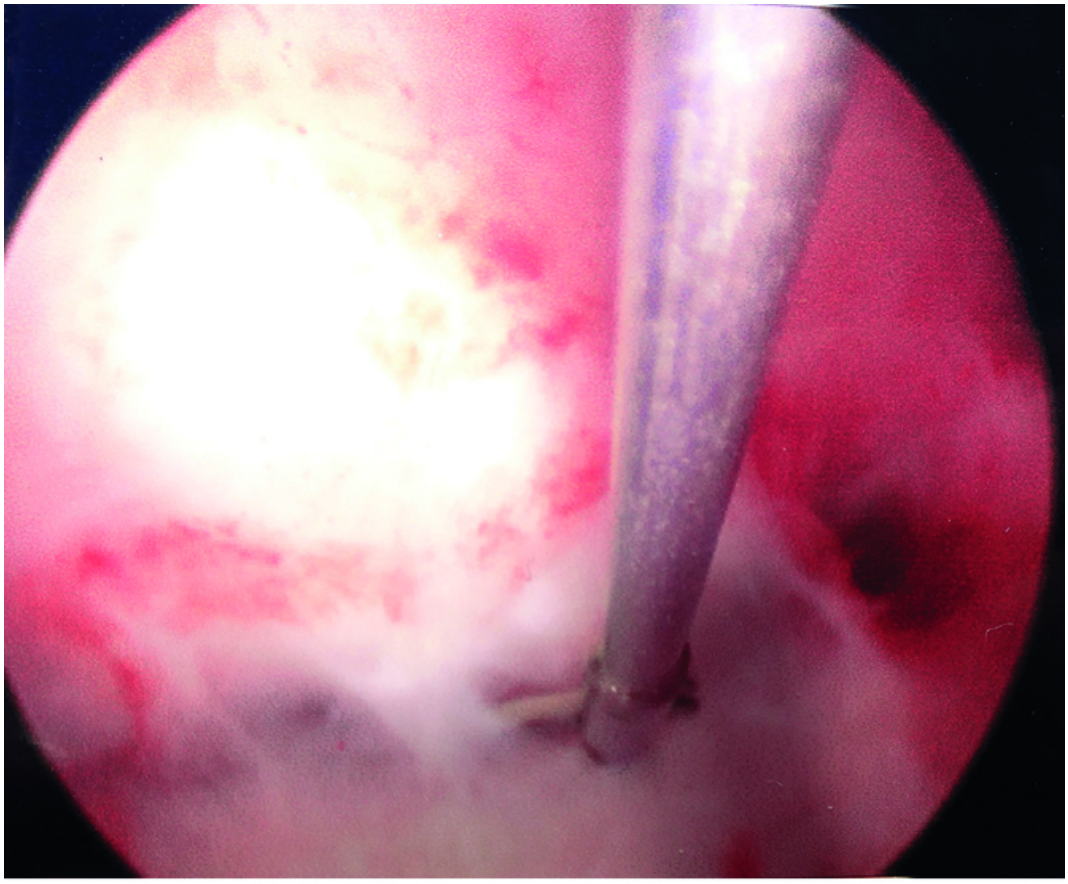

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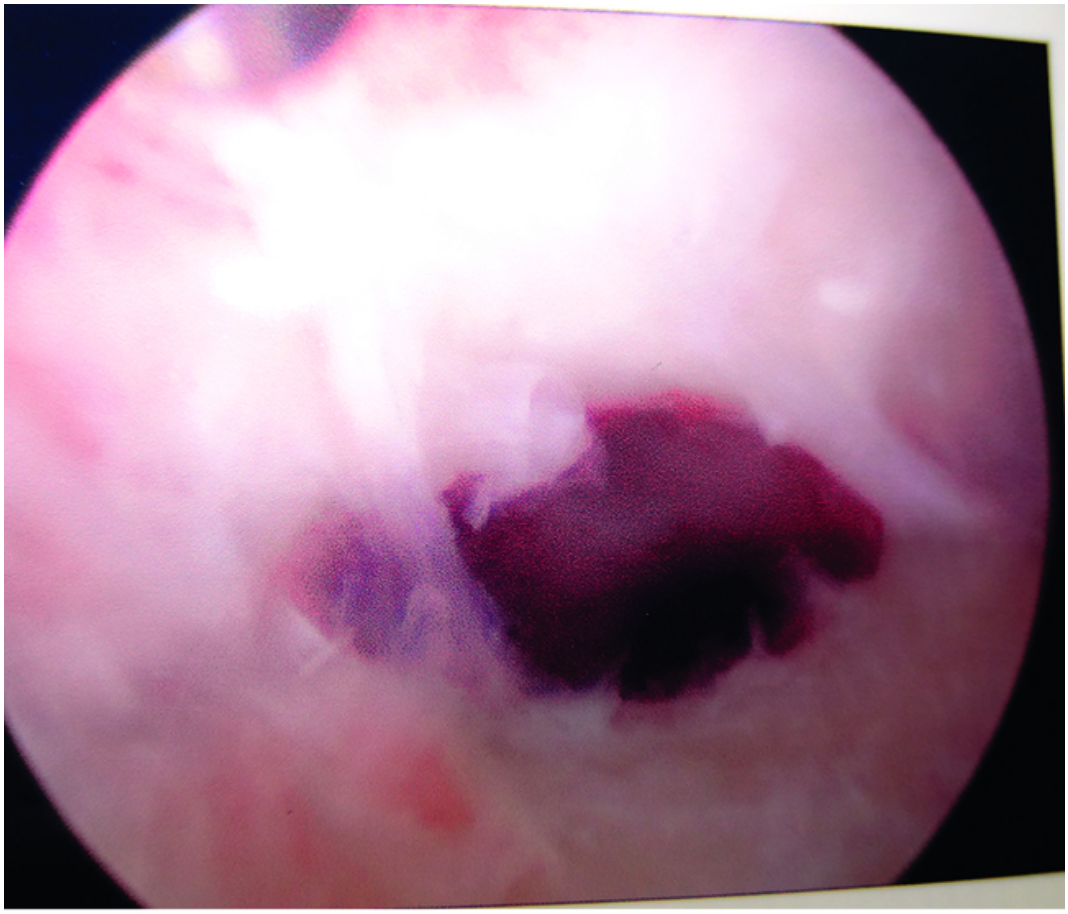
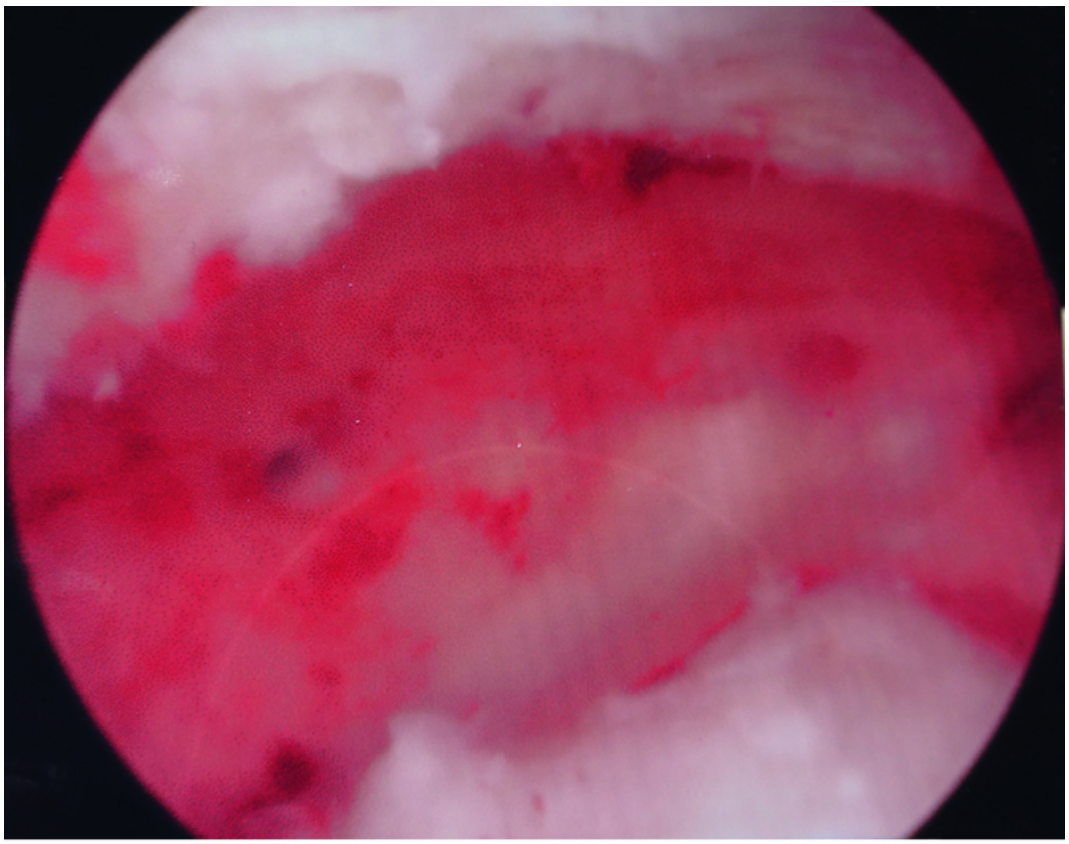


**D**



E

**FIGURE 15.15** **A.** A thin transverse adhesion spanning the intrauterine cavity between the lateral and anterior-posterior walls. **B.** Hysteroscopic Mayo scissors used to incise the adhesion. Note: due to high risk for uterine perforation, no electrocautery is used. **C.** Incision moving laterally. **D.** Opening into the upper/superior portion of the uterine cavity now visualized. **E.** Complete visualization of the newly opened intrauterine cavity.

## *Hysteroscopic Technique*

A thorough diagnostic hysteroscopy is performed to assess the degree of adhesion formation and deformity of the cavity. Small openings in the curtain of adhesions in which there are flow patterns of tiny blood fragments and tissue debris are helpful and should be sought out, as are any normal anatomic landmarks.

Simultaneous laparoscopy or ultrasound guidance is often prudent to prevent and immediately recognize perforation of the uterus. Flexible or semirigid scissors, a resectoscope or the Nd:YAG laser, are the operating instruments of choice, although some operators use the monopolar needle electrode at 40-50 W of cutting power, blend 1 or 2. When used, the Nd:YAG laser is initially set to deliver 30-50 W of power. The medium is instilled into the cavity by way of an operating sheath. Filmy and central adhesions should be cut first, always following the fluid flow. Marginal and dense adhesions should be addressed last, always cutting from below and moving upward. A key strategy is to maintain the hysteroscope in midchannel relative to the uterine walls. The cavity can usually be restored to reasonably normal architecture. Bleeding is not uncommon during this operation, particularly when cutting marginal adhesions, because the border between adhesion and myometrium is blurred.

Except in cases of one or two simple filmy adhesions, the patient should be placed on estrogen therapy during postoperative recovery. A recommended time period is for 14-28 days postoperatively. Recommended dose is 2.5-mg oral conjugated equine estrogens daily or 6-mg oral estradiol daily. Placement of a balloon device such as a pediatric Foley catheter balloon or IUD within the cavity to keep the walls from adhering is a standard postoperative measure. (A previously available triangular uterine stent is no longer commercially available at the time of publication of this chapter.) The Foley catheter balloon is typically kept in place for 7-10 days following the procedure and then removed in the office. While balloon is in place, the patient should be treated with an oral antibiotic such as doxycycline 100 mg by mouth twice daily for infection prophylaxis. Two studies have demonstrated that use of a distension device such as a balloon catheter after hysteroscopic adhesiolysis can decrease the rate of adhesion recurrence compared to no intervention.

# Cannulation of the Fallopian Tube

Hysteroscopy, often with simultaneous laparoscopy, can be used to treat fallopian tube obstruction. Novy et al. (1988) described a technique for passing a special catheter into the tubal ostium and through the obstructed interstitial portion of the tube. Dumesic and Dhillon (1991) reported a tubal cannulation procedure in which they used a flexible guiding insert to facilitate passage of the cornual cannulation catheter. These techniques are useful for treating interstitial obstruction secondary to cellular debris and tubal spasm. The obvious advantage of this cannulation technique is its usefulness in treating cases that might otherwise require *in vitro* fertilization or tubocornual anastomosis.

## *Hysteroscopic Technique*

A 5.5-F Teflon cannula with a metal obturator (Novy Cornual Cannulation Set, Cook Medical, Bloomington, IN) is introduced through the operating channel of the hysteroscopic sheath. The obturator is removed. A 3-F catheter with a guide cannula wire is introduced into the 5.5-F cannula by way of a Y-adapter on the end of the cannula, engaged into the tubal ostium, and gently advanced into the tube. When the cornual portion of the tube is negotiated or when resistance is encountered, the guidewire is withdrawn and indigo carmine dye injected through the 3-F catheter. Simultaneous laparoscopy allows the surgeon to see the dye exiting the fimbriated end of the tube and confirm patency (**FIG. 15.16**). Alternatively, one can place a radiologic plate beneath the patient and inject radio-opaque dye.

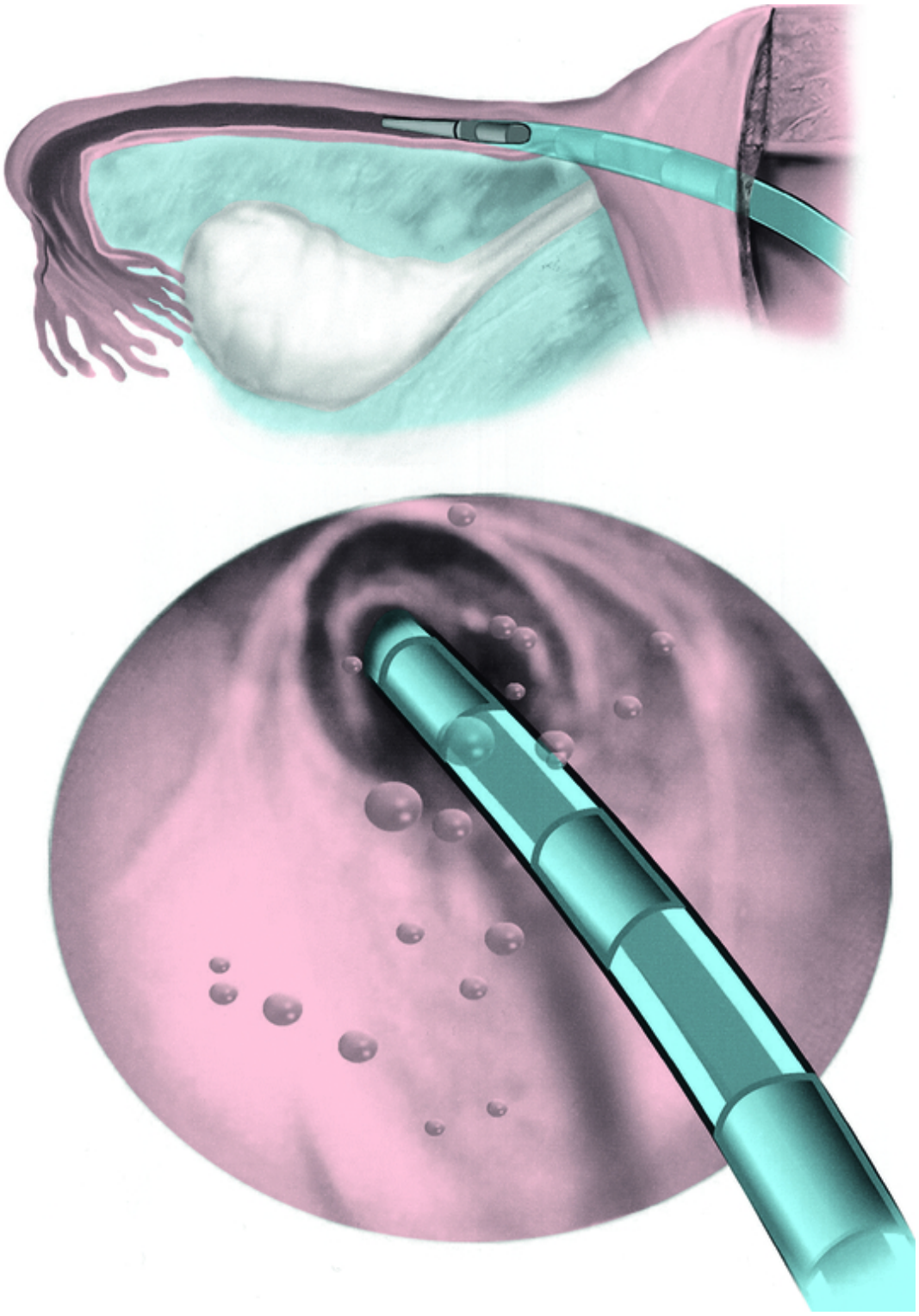


**FIGURE 15.16** An inner guidewire is inserted via direct hysteroscopic view into the tubal

ostium and advanced. An outer cannula is then advanced over the guidewire. Indigo carmine may be injected to demonstrate tube patency to an assistant viewing from above via laparoscopy. (Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

## Sterilization

Surgical methods of performing female sterilization from tubal ligation to total salpingectomy are discussed in other chapters of this book. Attempts to perform female sterilization hysteroscopically using plugs or causing proximal obstruction by electrical or chemical means have been attempted in the past. High complication and failure rates resulted in cessation of their use. In November 2002, the Food and Drug Administration (FDA) approved the use of the Essure microinsert, which is inserted hysteroscopically. Although Essure was widely used, safety concerns emerged and the manufacturer halted U.S. sales in 2018.

## Endometrial Ablation

Endometrial ablation is the surgical destruction of the endometrium. This procedure is ideally performed in patients who have chronic, ovulatory, heavy menstrual bleeding. Ablation has also been used to treat acute, abnormal uterine bleeding in patients who have failed, or who have contraindications to, medical therapy. Endometrial ablation is not intended as a treatment option in patients who desire future

childbearing, in patients with endometrial cancer or hyperplasia, or in postmenopausal patients with bleeding.

The goal of the ablation operation is to destroy the visible endometrium, including the cornual endometrium, to a depth of 1-2 mm. The conduction heat will actually spread deeper, usually to 3-5 mm, depending on how long the device remains on the tissue. This penetration translates into extensive superficial myometrial destruction and coagulation of the radial branches of the uterine cavity. When the endometrium sloughs, regeneration is prevented because basal and spiral arterioles do not survive the 100 °C heat exposure. Over a period of 6-8 weeks, the uterine walls scar and shrink.

Endometrial sampling should be performed in all patients undergoing ablation to rule out hyperplasia or carcinoma. Preoperative evaluation with saline infusion sonohysterogram, office diagnostic hysteroscopy, or MRI should be performed to evaluate for other causative pathology such as polyps, submucosal fibroids, and/or adenomyosis, as these conditions may alter treatment recommendations, outcomes, or counseling.

First-generation endometrial ablation refers to resectoscopic techniques to ablate, or resect, the endometrium. These procedures are done under hysteroscopic visualization using the rollerball, loop, vaporizing electrode, or laser.

Second-generation endometrial ablation devices are disposable and use nonresectoscopic techniques to ablate the endometrium. Devices currently approved by the FDA are bipolar radiofrequency (NovaSure, Hologic Inc., Marlborough, MA), cryoablation (Her Option, CooperSurgical, Trumbull, CT), circulating hot fluid (Genesys Hydrothermal Ablation, Boston Scientific, Marlborough, MA), and combined thermal and bipolar radiofrequency (Minerva, Minerva Surgical, Redwood City, CA). See **TABLE 15.2** for mechanism of action and specifics for each device.

## TABLE 15.2
## Second-Generation, Nonresectoscopic,

## Endometrial Ablation Methods FDA Approved in the United States

| | BIPOLAR RADIOFREQUENCY (NOVASURE) | CRYOABLATION (HER OPTION) | HYDROTHERMAL ABLATION (MINERVA) | COMBINED THERMAL AND RADIOFREQUENCY (MINERVA) |
|---|---|---|---|---|
| Mechanism | Bipolar mesh probe delivers radiofrequency current to the surrounding endometrium until reaching specific tissue impedance | An ice ball forms around the tip of a probe cooled by liquid nitrogen or differential gas exchange. Temperature reaches −20 °C, 3-5 mm from edge of ice ball, permanently destructive to tissue | Heated (90 °C) saline is administered into the uterine cavity through a hysteroscopic sheath inducing thermal destruction of surrounding endometrium | Electrical current ionizes argon into plasma, which heats surrounding silicone membrane. This heat, along with radiofrequency current, conducts to endometrial tissue |
| Device diameter (mm) | 7.5 | 5.5 | 7.8 | 7.0 |
| Uterine cavity length (cm) | ≥6 to ≤10 | ≥4 to ≤10 | ≥6 to ≤10.5 | ≥4 |
| Uterine cavity width (cm) | ≥2.5 | Not specified | Not specified | ≥2.5 |
| Duration of energy delivery | 90–120 s | 10 min | 10 min | 120 s |
| Endometrial pretreatment | None | GnRH agonist | D and C or GnRH agonist | None |
| Additional equipment | None | Ultrasound | Hysteroscope | None |

The second-generation devices are intended to require less surgical skill than necessary for the first-generation resectoscopic techniques. With the exception of the hydrothermal ablation, second-generation devices do not utilize a hysteroscope. However, hysteroscopy should be considered when utilizing any of these devices if the uterine cavity has not been evaluated preoperatively or if preoperative evaluation suggested a polyp or fibroid (with intention to treat). Aside from devices using bipolar radiofrequency, which measures effect by tissue impedance, endometrial pretreatment with GnRH agonist is recommended to optimize treatment effect.

# *Efficacy and Complications*

With appropriate patient choice, all ablation techniques are associated with high success and low failure rates. Most studies have reported up to 90% improvement in bleeding and 20%-70% amenorrhea rates. However, up to 25% undergo hysterectomy within 2-5 years. The following scenarios warrant special consideration prior to proceeding with endometrial ablation.

1. For patients at risk of endometrial cancer, there is concern that endometrial ablation could mask symptoms of endometrial

cancer (bleeding) or lead to a delay in the diagnosis due to difficulty sampling. Accordingly, progesterone therapy is preferred to ablation for the treatment of abnormal uterine bleeding secondary to chronic anovulation.

2. Endometrial ablation is not a treatment for fibroids or polyps. There is not an agreed-upon size of fibroid or polyp that excludes treatment with ablation. Aside from a small (<3 cm), type 2 fibroid, any polyp or fibroid should be removed prior to, or concurrent with, endometrial ablation.
3. Increasing uterine cavity size should raise suspicion for other pathology such as fibroids or adenomyosis. In the setting of a large uterus, consider a first-generation approach or hydrothermal ablation (circulating hot fluid) to ensure treatment of all surface area. Adenomyosis is not a contraindication to endometrial ablation. However, the risk of failure is higher since ablation does not treat the underlying pathology. Also, adenomyosis is a risk factor for postablation pain.
4. Patients with a previous tubal ligation are at risk for postablation tubal sterilization syndrome (PATSS), which presents as cyclic pain secondary to occult bleeding into obstructed tubes. This condition is estimated to occur in up to 10% of patients undergoing ablation with previous tubal ligation.
5. For patients <45 years of age at the time of the procedure, there appears to be a higher risk of failure and need for additional intervention than older patients.

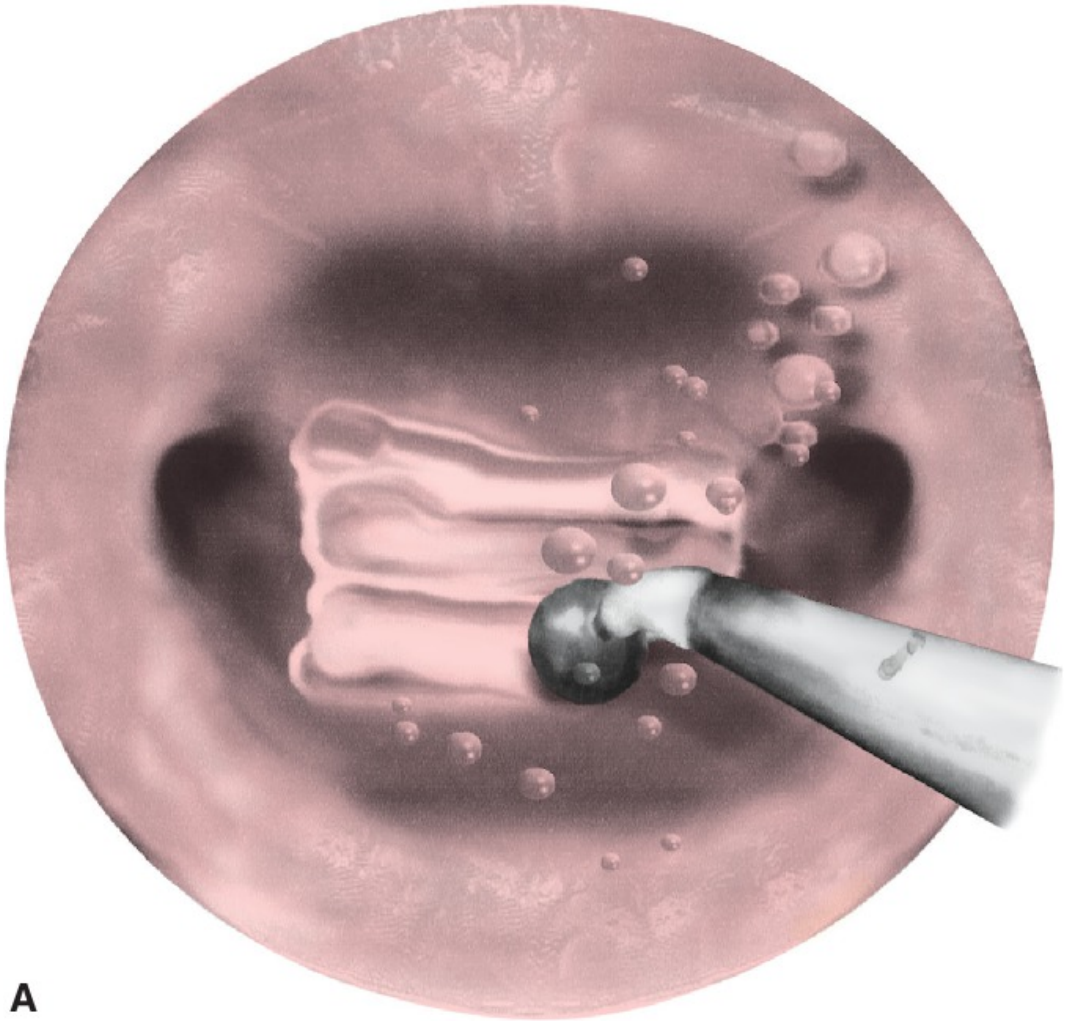
All risks of hysteroscopy apply to endometrial ablation. The incidence of overall complications is low and major complications are rare. The most common complications specific to endometrial ablation include uterine perforation (<1.3%), hemorrhage (<3%), hematometra (<2.4%), and pelvic infection (<2%). Specific to the hydrothermal ablation system, skin and vaginal burns have been described. The risk of uterine perforation is higher in resectoscopic ablation (1.3%) vs nonresectoscopic techniques (0.3%). Many of the second-generation devices have a built-in safety feature so that energy will not be deployed if there is suggestion of perforation or leak. Hematometra can occur when scarring of the uterus or cervix

occurs postablation. The overall risk is low (0.3%-2.4%) but is higher in resectoscopic ablation. For this reason, attempts should be made to avoid the cervix and cervicouterine junction when performing an ablation.

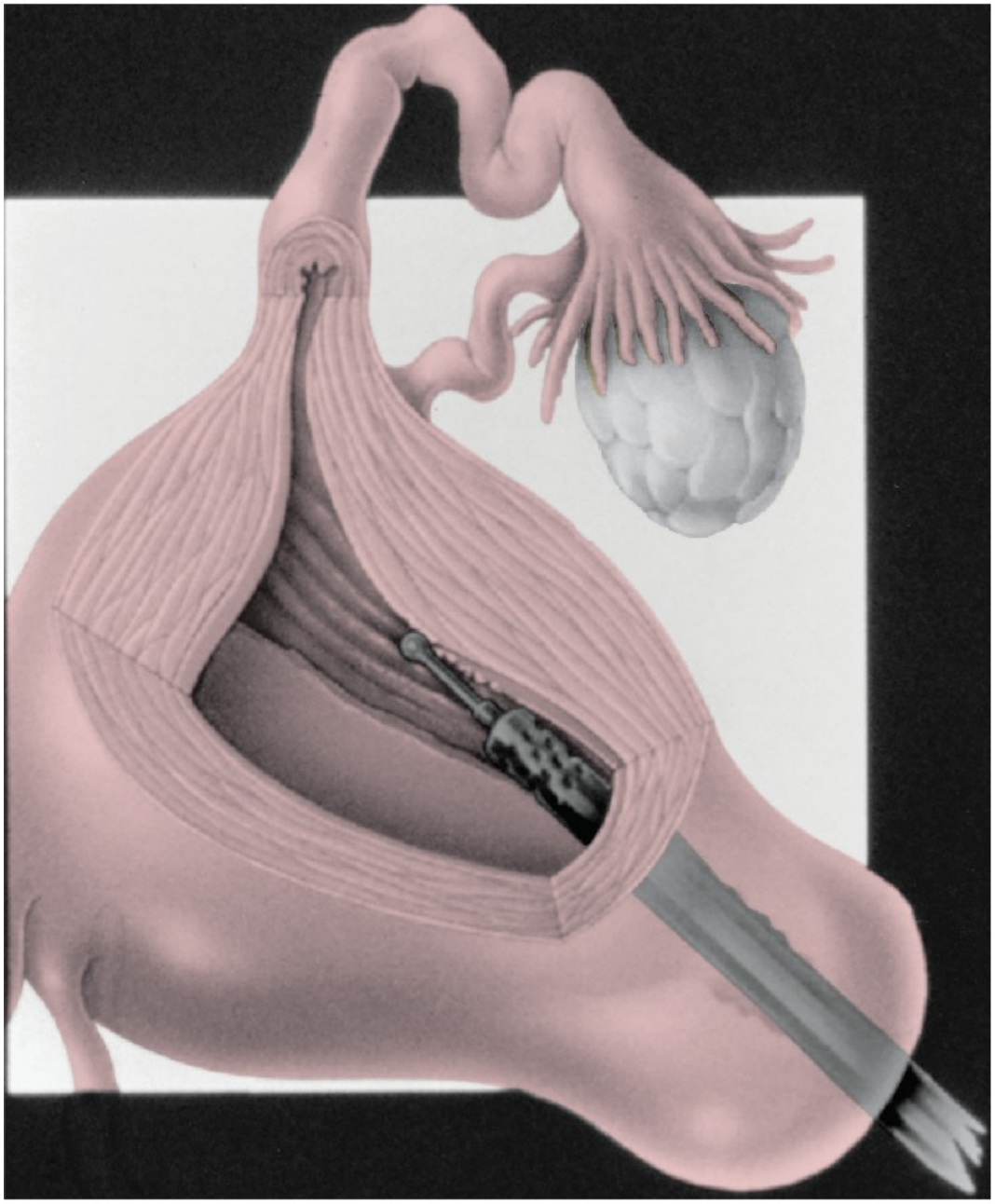
## *Hysteroscopic Technique*

Prior to endometrial ablation, hormonal treatment is often recommended to control abnormal uterine bleeding. Patients with persistent heavy menstrual bleeding, who do not desire future childbearing, and who do not have structural cause to account for bleeding, may be candidates for endometrial ablation. A preoperative diagnostic hysteroscopy, endometrial sampling, or both should be performed to exclude endometrial carcinoma or atypical hyperplasia, and all pertinent hematologic studies and consultations should be performed.

Prior to endometrial ablation with resectoscopy, patients are pretreated with medication such as a GnRH agonist to achieve endometrial atrophy. Simultaneous laparoscopy is not performed during endometrial ablation unless a perforation or other transmural injury is suspected. Power settings for the electrosurgical generator range from 50 to 150 W, depending on the size of the ball, barrel, or loop electrode. Laser power is set at 40-60 W. Depending on the endometrial resection technique selected, either 5% mannitol or 0.9% saline is used as the distension media. The operating hysteroscope or resectoscope is inserted into the uterine cavity. The fundal endometrium is ablated first. One method to treat the fundus is by dragging the laser fiber or the ball electrode from side to side (cornu to cornu) (**FIG. 15.17**). The anterior and lateral walls are ablated next, before the posterior wall. In an effort to prevent cervical stenosis, ablation should not be extended below the internal os into the cervix.



A



B

**FIGURE 15.17** **A.** The ball electrode is dragged from side to side via moving the entire hysteroscope, thereby ablating the uterine fundus. **B.** The anterior and posterior walls are ablated by dragging the energized

ball electrode from above downward. This creates 2- to 3-mm furrows in the endometrium. Conduction heat damage can extend another 1-2 mm. (Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

The mean duration of the operation is about 30 minutes. Patients usually are sent home on the day of surgery. The operation is usually completed with little or no blood loss. Subsequent sampling or hysteroscopy is possible after endometrial ablation.

# Miscellaneous Procedures

## *Intrauterine Device Removal*

It is occasionally necessary to search for and remove an IUD with a string that is not seen in the cervix. In such circumstances, operative hysteroscopy is useful to locate the device and remove it under direct visualization. The hysteroscope is inserted, and the device is viewed. If a string is seen, an alligator jaw forceps is inserted, and the string is grasped. The hysteroscope is withdrawn, pulling the device out of the uterus. If the IUD is embedded, then a rigid grasping forceps is required. The IUD is located, and the large jaws of the rigid instrument grab the extruded portion of the IUD itself. Strong pressure is exerted on the jaws as the sheath of the hysteroscope is slowly withdrawn.

## *Biopsy of Intrauterine Lesions*

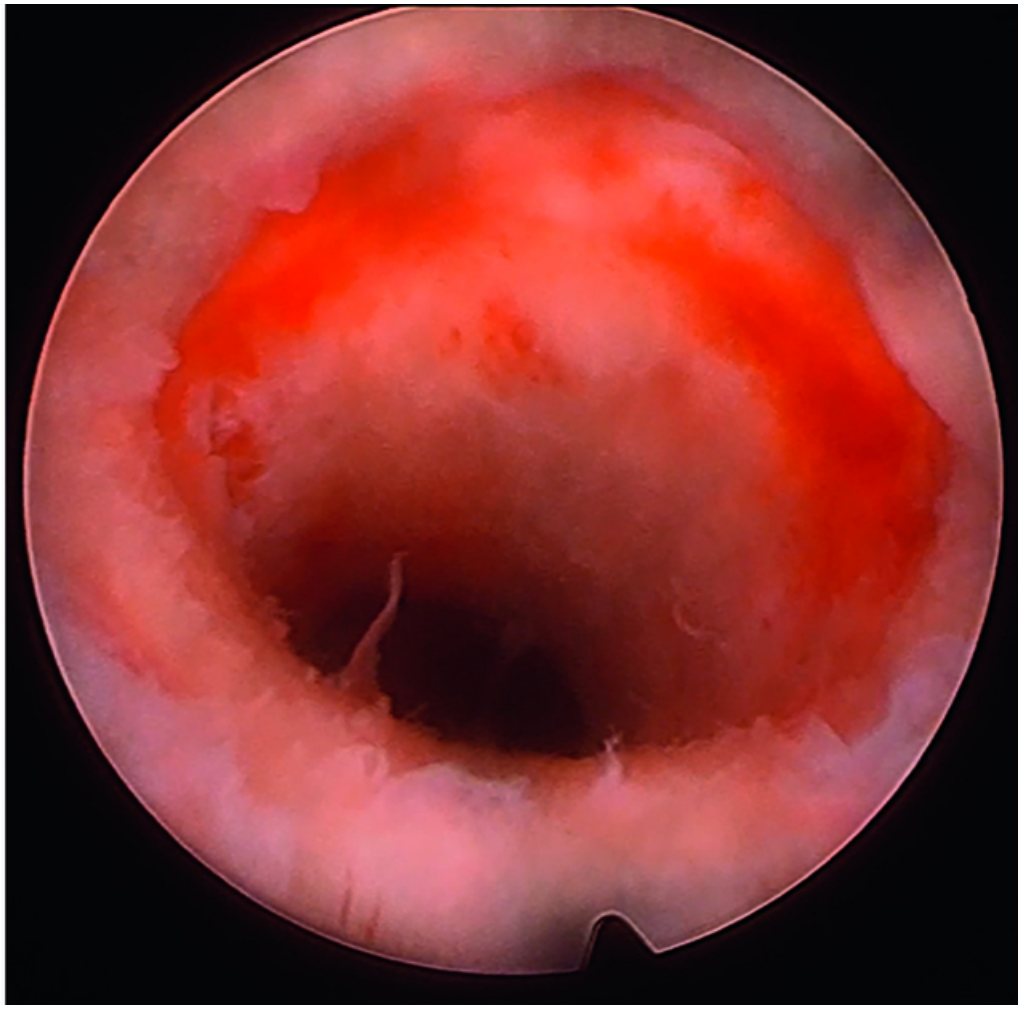
Hysteroscopy has evolved as a method to allow directed biopsies of the uterine cavity to rule out malignancy. When a tumor is suspected, the operative hysteroscope is inserted into the cavity, a 9-F biopsy forceps is directed to the tumor site, and multiple biopsy specimens are obtained in a fashion analogous to that used with colposcopic biopsies. To extract the tissue, a 9-F plastic cannula is inserted by way of the operating channel, and strong suction is applied to the mouth of the cannula by means of a 30-mL syringe. The cannula is removed, and the contents are flushed out with saline into a bottle of fixative. Similarly, a 9-F curette can be inserted under direct vision. Alternatively, a diagnostic hysteroscope can be used to identify the site of pathology. The endoscope is then withdrawn, a Novak curette is inserted into the cavity, and biopsy specimens are taken at the previously located site. Finally, the hysteroscope is pulled back to the level of the internal cervical os, a small Novak curette is inserted alongside the hysteroscope, and a directed biopsy specimen is obtained.

# *Repair of Cesarean Scar Defects*

A Cesarean scar defect, often referred to as an isthmocele, is a pouchlike defect that arises at the site of a prior Cesarean section (C-section) incision site. Studies suggest that menstrual blood or fluid can accumulate in the pouch and cause symptoms such as abnormal uterine bleeding, pain, and infertility. C-section scar defects can also result in an increased risk of abnormal pregnancy or complications such as C-section scar ectopic, abnormal placentation, and uterine rupture.

Saline infusion ultrasound or MRI is recommended for detection. The C-section scar defect is defined as an indentation of >2 mm at the site of previous hysterotomy. On hysteroscopy, a C-section defect will appear as a pouch of the lower anterior uterine wall (assuming previous low segment transverse C-section) with superior and inferior edges that may be fibrotic (FIG 15.18A and B). Correction of the C-section defect may be considered to improve abnormal uterine bleeding or infertility. Different routes of repair include hysteroscopic, vaginal, abdominal, and laparoscopic/robotic.

In general, hysteroscopic repair of a C-section defect should be reserved for patients who do not plan future pregnancy.



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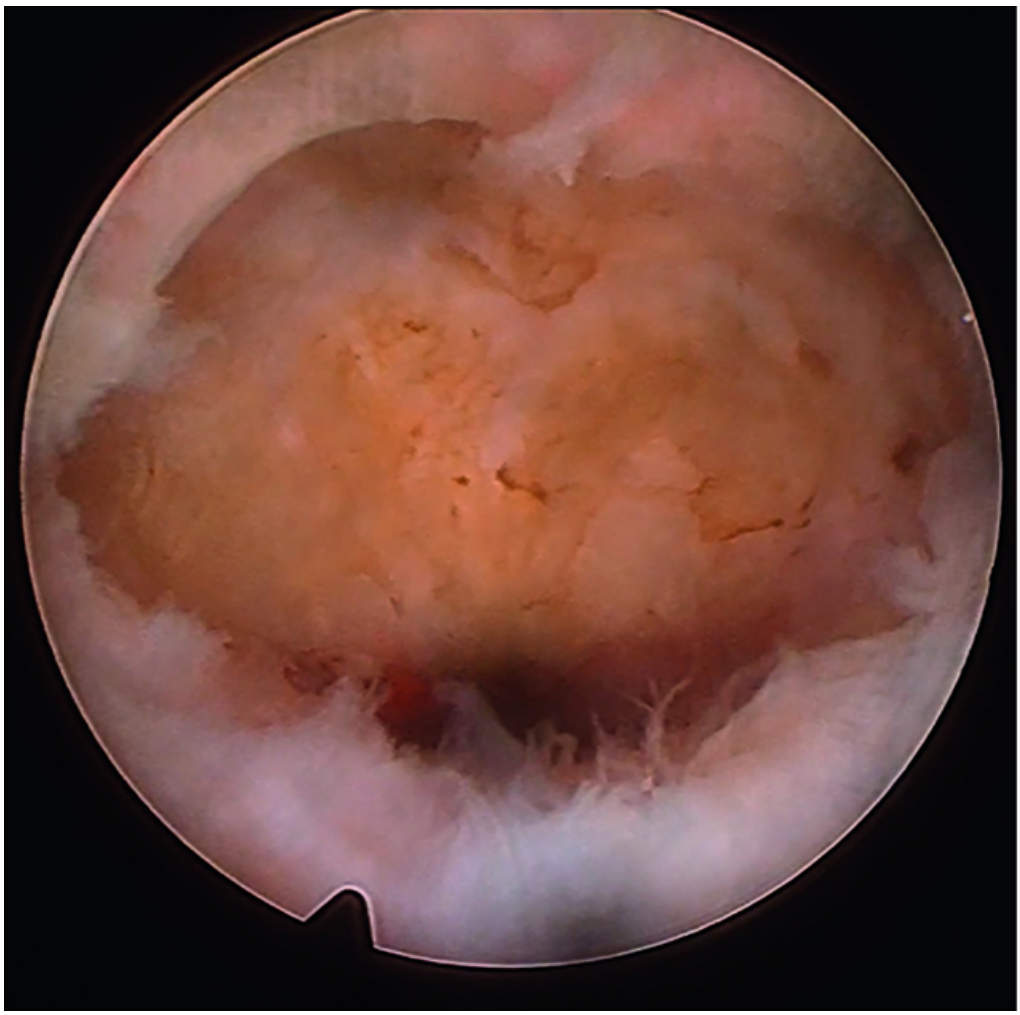

B

**FIGURE 15.18** **A.** Uterine C-section scar defect prior to hysteroscopic resection. It is identified by outpouching into the anterior uterine segment with a notable space where fluid can accumulate. **B.** After hysteroscopic repair, the “niche” is less likely to result in fluid accumulation. (Photos courtesy of Bala Bhagavath, MD.)

Hysteroscopic correction techniques include the following:

a. Resection of the edges and/or fibrotic ring of the defect using the loop of a bipolar resectoscope.
    - This effectively eliminates the deep pouch and creates a "valley" where blood will not stagnate.
b. Fulguration of the base of the pouch using a rollerball.
    - This is theorized to destroy exposed blood vessels, correct any residual diverticulum, and induce scar retraction of the pouch. It's recommended to perform fulguration under transabdominal ultrasound guidance to help prevent inadvertent thermal injury to bladder or surrounding structures as there is commonly minimal myometrium overlying the defect.
c. Combination of the two techniques described above.

Most studies on hysteroscopic correction of a C-section scar defect examine improvement in postmenstrual abnormal bleeding as their primary outcome. A 2020 meta-analysis by Vitale et al. reported 65%-100% symptom improvement in a total of 449 patients from 12 studies. There are limited data to critically evaluate the impact on fertility or obstetric complications.

# COMPLICATIONS

Hysteroscopic complications include bleeding, uterine perforation, creation of false passages, and excess fluid absorption and subsequent pathologic responses. Overall, complications are rare. In a multicenter study that included over 21 676 hysteroscopic procedures from 92 centers, Aydeniz et al. (2002) reported an overall complication rate of 0.22%. Incidence of specific complications included uterine perforation (0.12%), fluid overload (0.06%), intraoperative bleeding (0.03%), bowel and bladder injuries (0.02%), and infection (0.01%). Jansen et al. (2000) reported a 0.28% complication rate among 13 600 hysteroscopic procedures including 82 centers. Diagnostic hysteroscopic procedures had a significantly lower complication rate (0.13%) than operative procedures (0.95%) with lysis of adhesions having the highest

complication rate, 4.48%, among procedure types. Uterine perforation was the most frequent surgical complication with a rate of 0.76%; 54.5% of those occurred during entry.

## Uterine Perforation

Uterine perforation can occur during any operative hysteroscopy procedure but is most common during septum resection, myomectomy, and lysis of adhesions. Simultaneous laparoscopy or ultrasound guidance can be performed in anticipation of challenging cases to help prevent this complication. As uterine perforation often occurs during the dilation, prior to actually placing the hysteroscope, there has been much interest in optimizing the dilation process to avoid perforation and other complications such as creating a false passage and cervical laceration. To help prevent perforation during entry, the cervix and internal os should be negotiated under direct visualization, and the cavity should likewise be entered under direct visualization. Examination under anesthesia can provide the direction of the uterine axis, and simultaneous transabdominal ultrasound can also help guide the surgeon in navigating a difficult cervical canal.

As noted above, the most dangerous perforations are those associated with lasers and electrosurgical devices. The risk of this type of injury can be reduced by not activating the energy device during a thrusting or forward movement. The foot pedal is activated only during the return phase of the laser fiber or electrosurgical electrode. If a perforation does occur with an energy device, then laparotomy or laparoscopy is required to ensure that no injury has been inflicted on the intestine, bladder, or ureter.

Perforation risk is highest with septum transection in its final phase at the level of the uterine fundus because the operator may have difficulty determining where the septum ends and myometrium begins. One sign of perforation is sudden loss of distension as media exits at the perforation site (**FIG. 15.19**). If perforation is unnoticed and if simultaneous laparoscopy is not performed, a serious complication is possible even with a nonenergy instrument, but this is far less common than those occurring with lasers or electrodes.

Injuries to the iliac vessels can occur as the result of uterine perforation. An unexplained falling blood pressure, together with medium leakage, should alert the surgeon to this possibility. If perforation is suspected, options include laparoscopy for evaluation vs an extended observation postoperatively. Perforation of the uterus during hysteroscopy can place a woman at an increased risk for uterine rupture during a future pregnancy.

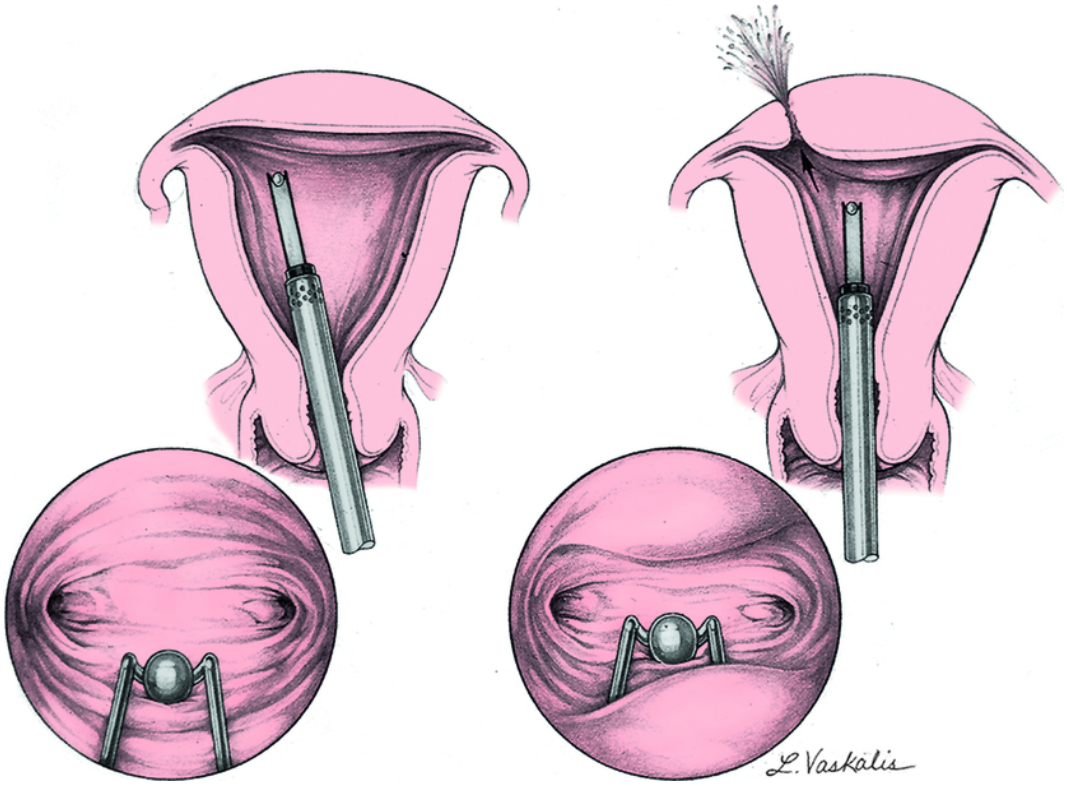


**FIGURE 15.19** Perforation should be immediately suspected when the endometrial cavity depressurizes and collapses around the hysteroscope, creating a compromised view of the cavity. (Reprinted with permission from Baggish MS, Valle RF, Guedj H. *Hysteroscopy: Visual Perspectives of Uterine Anatomy, Physiology and Pathology*. 3rd ed.

Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

## Management of Fluid Overload

The pathophysiologic ramifications of fluid overload can be severe and life threatening. Therefore, the gynecologic surgeon must be vigilant in preventing this important complication. The risk of complications varies with the distension medium.

Methods to prevent fluid overload include the following: (1) use isotonic fluids such as normal saline whenever possible, (2) monitor the fluid deficit closely, (3) use a weight-based fluid management system, (4) maintain intrauterine fluid pressure at 70-80 mm Hg, and (5) limit surgical operating time to 1 hour or less. Serious complications due to hyponatremia have been reported from use of hypo-osmolar fluids such as sorbitol and glycine. For instance, absorption of 1000 mL of glycine distension medium during hysteroscopy is associated with a reduction in serum sodium of ~10 mEq/L. The American College of Obstetricians and Gynecologists' Committee on Gynecologic Practice recommends termination of a case with a deficit of 750 mL with hypo-osmolar fluids when the patient is elderly or has comorbid conditions. The case should be terminated for a deficit of 1000 mL for all other patients. When an isotonic distension medium is used, the case should be terminated when the deficit reaches 2500 mL. If maximum fluid deficit is reached, especially when using a hypotonic solution, a stat sodium level should be sent and the patient may need to be treated with a loop diuretic such as furosemide. Severe hyponatremia typically requires admission to an intensive care unit; the patient should be managed in cooperation with an intensive care specialist and may require hypertonic saline.

## Intraoperative and Postoperative Bleeding

Common complications of hysteroscopic surgery include intraoperative and postoperative bleeding. Intraoperative bleeding can be managed by increasing the pressure of the distension media so that it exceeds arterial pressure, compressing the uterine walls sufficiently to stop bleeding. The bleeding vessel can then be coagulated with a 3-mm ball electrode with forced coagulation at 30-40 W of power or by multiple pulses with bipolar needles at 20-30 W of power with the generator set for automatic bipolar. If the counterpressure of the medium is relaxed (at the termination of the procedure) and bleeding continues, then control is best obtained by inserting an intrauterine balloon initially inflated to 2-5 mL. If this pressure does not promptly stop the bleeding, then a larger balloon can be distended to 10 mL until the bleeding has stopped. More distension may be required for larger uteri. Care must be taken to prevent overinflation of an intrauterine balloon, which can itself rupture the uterus. The balloon remains in place for 6-12 hours, is partially deflated for 6 hours, and, finally, is totally deflated before removal. When the bleeding is pulsatile, the source is arterial rather than venous. If this type of bleeding is not immediately controlled by balloon compression, then emergent hysterectomy or uterine artery embolization will usually be required. Delayed postoperative bleeding is most commonly associated with endometrial slough (after ablation), chronic endometritis, or spontaneous extrusion and expulsion of the intramyometrial portion of a previously resected submucosal myoma.

## Poor Visibility in the Operative Field

Poor visualization of the operative field is a common problem. A frequent reason is deep insertion of the hysteroscope such that the telescope is in direct contact with the endometrium. A natural tendency is to push the hysteroscope deeper, which can lead to perforation. Another cause of poor visibility is blood within the uterine cavity secondary to dilatation. The optimal method to address a bloody cavity is rapid flushing with the hysteroscopic medium combined with aspiration.

Overdilation of the cervix is an equally common mistake that results in excessive leakage of distension media and an inability to maintain distension, with the resultant inability to perform the operative hysteroscopy. Blood and debris can cloud the field to such a degree that accurate operative endoscopy is impossible. If the operator cannot clearly see the field, it is better to discontinue the procedure rather than press on. It is easy to become disoriented in the uterine cavity if normal anatomic landmarks cannot be recognized.

# Gas Embolus

Gas embolism is a well-documented complication of operative hysteroscopy using $CO_2$ as the distension media. Brandner et al. (1999) reviewed 3932 cases and found a 0.51% incidence of subclinical events and a 0.03% incidence of symptomatic events related to gas emboli. A catastrophic $CO_2$ gas embolism is especially likely to occur if a laparoscopic $CO_2$ insufflator is connected to the diagnostic hysteroscope; therefore, the surgeon must be vigilant in preventing this.

Air embolism may also occur during operative hysteroscopy when fluid distension media are used. Introduction of ambient air into the uterine cavity by repeated passes of the hysteroscope or by creation of vapors by use of electrosurgery is thought to be responsible for causing air emboli. Air then passes into venous sinuses of the uterus either passively or actively from the pressure of the liquid media. Findings that suggest this complication include a decrease in end-tidal $CO_2$, which is nonspecific, and a millwheel murmur. Transesophageal echocardiography appears to be the most sensitive and specific monitoring method. If a gas embolism is suspected, the procedure should be stopped immediately. Avoiding Trendelenburg position during operative hysteroscopy has been suggested to decrease risk of gas embolism.

# Infection

Infection is an uncommon complication of hysteroscopy. Salat-Baroux et al. (1984) reported 7 infections out of 4000 hysteroscopic examinations. Agostini et al. (2002) reported 30 infections associated with 2116 operative hysteroscopies with 18 cases of endometritis. Hysteroscopy should be avoided in the presence of known cervical infection, uterine infection, or salpingitis. Infection is otherwise uncommon, including in the setting of extensive intrauterine surgery (eg, adhesiolysis or myomectomy). Prophylactic antibiotics are not recommended by the ACOG for diagnostic or operative hysteroscopy.

## Equipment Failure

Diagnostic and operative hysteroscopic procedures utilize complex equipment requiring attention for correct instrument assembly, connection to electrical or laser energy sources, as well as connections to video cameras and monitors for proper administration of distension media. In a prospective observation study by Courdier et al. (2009), equipment failures were divided into four categories: imaging, transmission of fluids and light, the electric circuit, and surgical instruments. During 51 operative hysteroscopies, 37.3% (19) were complicated by equipment failures. Most common problems included nonavailable or damaged hysteroscopic connections and fittings, faulty connections, or an incorrect setting of the suction system. Surgeon or staff error contributed to many of the documented errors. Surgeons performing diagnostic and operative hysteroscopy should be able to assemble and disassemble the hysteroscopic instruments, be able to connect and activate the video monitoring systems, and be capable of operating the hysteroscopic fluid monitoring systems. Creation of checklists for surgeons and assistants to review prior to performing the hysteroscopic procedure may be of value.

# POSTOPERATIVE CONSIDERATIONS

After diagnostic or operative hysteroscopy, patients go home the same day after a brief recovery. Patients can resume a regular diet

and activity as tolerated. Pelvic rest, including no intercourse or tampons, is generally recommended for a week. Patients with a uterine stent or balloon in place should be given precautions for infection and expulsion. Patients who undergo an extensive myoma resection may experience cramping and light spotting or vaginal bleeding for 1-2 weeks.

For patients desiring pregnancy, conception attempts may commence at the next menstrual cycle following a polypectomy or excision of a pedunculated myoma. For those who are status post resection of a myoma with an intramural component, it is generally recommended that patients wait 3 months before attempting conception. Time to proceed with conception attempts after lysis of adhesions or septoplasty is reliant on postoperative course but should proceed only after postoperative imaging demonstrates an open cavity with no new adhesion formation.

# KEY POINTS

- When cervical stenosis is anticipated, misoprostol pretreatment can ease entry through the endocervical canal into the uterine cavity.
- A clear, unobstructed view of the intrauterine cavity is necessary before initiating any hysteroscopic procedure.
- Infusion of liquid, low-viscosity media during operative hysteroscopy must be accurately measured and recorded, especially hypo-osmolar media such as glycine or sorbitol.
- Positive infusion differences require that the procedure be stopped when deficits range from 750 mL (for hypo-osmolar fluids) to 2500 mL (iso-osmolar fluids).
- Absorption of hypo-osmolar distension media can result in life-threatening hyponatremia so the surgeon must be vigilant in monitoring fluid deficits when these media are used.
- Carbon dioxide as a distension medium should only be used in diagnostic cases, and a hysteroscopic insufflator (not laparoscopic) must be used to reduce risk of gas embolism.

- Perforation during operative hysteroscopy with an energy device requires laparoscopy or laparotomy to inspect intra-abdominal structures for thermal injury. The choice of laparoscopy or laparotomy may be influenced by the index of suspicion for thermal injury.

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# CHAPTER 16

# SURGICAL MANAGEMENT OF ABORTION AND ITS COMPLICATIONS

Amy G. Bryant and Chava Kahn

**First Trimester Miscarriage**
Epidemiology of First Trimester Miscarriage
Diagnosis of First Trimester Miscarriage
Management of First Trimester Miscarriage
**First Trimester Induced Abortion**
Epidemiology
Legal Framework for Induced Abortion
Counseling Prior to Induced Abortion
Preoperative Evaluation
Prophylactic Medications for Vacuum Aspiration
Surgical Uterine Vacuum Aspiration
Medication Abortion
**Surgical Management of Second Trimester Pregnancy Loss and Induced Abortion**
Epidemiology
Counseling and Management Options
**Dilation and Evacuation**

Pre-procedure Medications and Preparation
Dilation and Evacuation Procedure
**Complications of Surgical Abortion**
Immediate Complications
Delayed Complications
Late Complications
**Abortion in Highly Restricted Settings**

This chapter focuses on the surgical management, and associated complications, of uterine evacuation for pregnancy loss and induced abortion. A brief overview of medical approaches is provided here. However, full detail is beyond the scope of this gynecological surgical textbook.

# FIRST TRIMESTER MISCARRIAGE

## Epidemiology of First Trimester Miscarriage

In the first trimester, the terms miscarriage, spontaneous abortion, and early pregnancy loss are used interchangeably, and there is no consensus on terminology in the literature. For the purpose of this chapter, we will use the definitions from ReVITALize. First trimester miscarriage refers to an intrauterine pregnancy within the first 13 6/7 weeks of gestation presenting with either an empty gestational sac or a gestational sac containing an embryo without fetal heart activity. The best way to describe a miscarriage or intrauterine pregnancy loss is to indicate (1) the number of weeks of amenorrhea and (2) the measurement of embryo/fetus, or the sac size if this was an anembryonic pregnancy.

First trimester miscarriage occurs in an estimated 10% of clinically diagnosed pregnancies. Risk factors and etiologies for first

trimester miscarriage are genetic, environmental, or multifactorial. The most common causes of first trimester miscarriage are chromosomal abnormalities. Autosomal trisomies are the most frequent chromosomal abnormalities, followed by polyploidies, and then monosomy X.

Environmental factors associated with first trimester miscarriage include alcohol consumption, tobacco use, and diet. Some studies have found that moderate amount of alcohol intake, such as more than three cups per week, doubles the risk of first trimester miscarriage. However, a safe level of alcohol consumption has not been established for any pregnancy stage, and therefore, alcohol in pregnancy should be avoided. Similarly, tobacco use in early pregnancy may result in a modest increase in first trimester miscarriage, and there may be a dose effect, although evidence is limited. Reports of the association between caffeine intake and first trimester miscarriage are conflicting. However, evidence suggests that consumption of more than two caffeinated beverages per day may nearly double the risk of first trimester miscarriage.

A patient's demographic factors and some maternal health conditions are also associated with her risk of first trimester miscarriage. Advancing maternal age and history of prior first trimester miscarriage are the most common risk factors. The rate of miscarriage at age 35 is 20% and increases sharply to 40% at age 40 and 80% at age 45. Similarly, the risk of first trimester miscarriage increases with each documented loss, from 20% after one loss to 43% after three or more. Maternal health conditions associated with an increased risk of first trimester miscarriage include endocrine disorders, such as poorly controlled diabetes and thyroid disease, autoimmune disease, and hypercoagulable states.

## Diagnosis of First Trimester Miscarriage

Patients with first trimester miscarriage may present with vaginal bleeding and uterine cramping, and some may report decreased pregnancy symptoms. Evaluation starts with a comprehensive

history and physical examination with particular focus on the patient's menstrual history and risk factors for ectopic pregnancy, such as history of sexually transmitted infections or pelvic or abdominal surgery. The physical examination should focus on the presence or absence of abdominal tenderness, blood in the vaginal vault, and products of conception at the cervix. A bimanual examination can exclude cervical or uterine tenderness, which could indicate septic abortion, or an adnexal mass or fullness, which could indicate an ectopic pregnancy.

Ultrasound, if available, is the preferred modality to evaluate and diagnose first trimester miscarriage. Many times, the diagnosis of first trimester miscarriage is straightforward, such as when an intrauterine embryo or fetus with a crown-rump length of ≥7 mm and no cardiac motion is clearly identified on ultrasound. In the absence of a measurable embryo, a gestational sac at least 25 mm in mean sac diameter has high specificity for first trimester miscarriage. Other times, a single ultrasound is not sufficient to make the diagnosis, and another ultrasound after 7 days or serial serum beta-hCG testing may be necessary.

Serial measurement of serum beta human chorionic gonadotropin (β-hCG) can be an important adjuvant tool to aid in the diagnosis of a normal or abnormal pregnancy (where abnormal pregnancy includes the diagnoses of first trimester miscarriage or ectopic pregnancy). The "discriminatory level" is the β-hCG serum level above which the presence of a possible gestational sac should be visible on ultrasound and when absence strongly suggests a first trimester miscarriage or ectopic pregnancy. When the discriminatory level of β-hCG is used as a diagnostic tool, the β-hCG value should be at least 3500 mIU/mL to avoid possible recommendation for interruption of a normal intrauterine pregnancy. Once the β-hCG level is above the discriminatory level, rechecking β-hCG is of limited value.

## Management of First Trimester Miscarriage

Clinical management of miscarriage includes expectant, medical, or surgical management. In general, a patient's preference should determine management, as long as she is hemodynamically stable and infection has been ruled out. Expectant and medical management is covered in this section. The surgical management of first trimester miscarriage is covered in sections that follow (First Trimester Induced Abortion).

Preoperative counseling and the informed consent process is as important for someone experiencing miscarriage as it is for any other procedure. The counseling includes discussion and options for expectant, medical, or surgical management and a thorough review of medical and surgical conditions and future fertility plans.

## *Expectant Management of First Trimester Miscarriage*

Awaiting spontaneous expulsion of the pregnancy is a safe option for most patients with first trimester miscarriage. Prior to 8 weeks gestation, expectant management is successful in ~80%. Limited data suggest that successful expectant management of miscarriage concludes at 8 weeks typically occurs within 2 weeks. Therefore, many clinicians will intervene if complete expulsion has not occurred by 2 weeks from the time of the miscarriage diagnosis.

Compared to surgical management of first trimester miscarriage, studies have found that expectant management is associated with a greater incidence of unplanned hospital admission and unplanned surgery. However, overall complication rates are similar, and patient preference should guide choice of intervention. Many clinicians will encourage a follow-up appointment both to confirm complete pregnancy expulsion and to assess for any possible psychological impact, since for many patients it can be an extremely emotional process.

## *Medical Management of First Trimester Miscarriage*

For patients who desire to shorten the time to complete pregnancy expulsion but also want to avoid surgical intervention, medical management is a safe and effective option. Medical management of first trimester miscarriage is similar to medication abortion, which is further discussed in the sections that follow.

Unlike induced medication abortion, medical management of first trimester miscarriage can be accomplished with misoprostol with or without mifepristone. Misoprostol is a prostaglandin E1 analogue. Mifepristone is a 19-nor steroid that acts as a competitive progesterone-receptor antagonist and primes the myometrium and cervix for prostaglandin activity.

The success of medical management for first trimester miscarriage is dependent upon the gestational age and the medication regimen. Among patients with miscarriage before 12 completed weeks of gestation who receive 200 mg of mifepristone followed by 800 μg of vaginal misoprostol 24 hours later, complete expulsion is achieved in 84% of cases. When 800 μg of vaginal misoprostol alone is used, complete expulsion by day 3 occurs in 71% of patients. The success of misoprostol alone is increased to 84% when a second dose of 800 μg of vaginal misoprostol is administered as needed within 7 days. The addition of mifepristone results in a success rate almost 20% higher than the success rate of expulsion after misoprostol alone, and thus this regimen should be considered first-line management for medical management of miscarriage.

## *Surgical Management of First Trimester Miscarriage*

Surgical management of miscarriage in the first trimester can be performed by uterine vacuum aspiration, using manual or electric uterine vacuum aspiration. Sharp curettage is an outdated surgical approach and carries far more risks than does suction curettage alone and should not be used. The procedure for vacuum aspiration of first trimester miscarriage is almost identical to the procedure for first trimester induced abortion. The technique of uterine vacuum aspiration is described later in the chapter.

# FIRST TRIMESTER INDUCED ABORTION

## Epidemiology

Induced abortion is one of the most frequently performed procedures in the United States. Induced abortion is also one of the safest procedures with a mortality rate estimated to be <1 in 100 000. In 2017, 862 320 induced abortions were reported in the United States. The national abortion rate in 2017 was 13.5 abortions per 1000 women aged 15-44, but these rates vary significantly by race and ethnicity. In 2014, White patients accounted for 39% of abortion procedures, Black patients for 28%, and Hispanic patients 25%. Patients of other races and ethnicities accounted for 9% of procedures. Structural barriers to contraceptive and health care access are thought to contribute to a higher proportion of Black and Hispanic patients obtaining abortion procedures.

## Legal Framework for Induced Abortion

Since the landmark Supreme Court decision of *Roe v. Wade* in 1973 that legalized abortion in the United States, states have passed 1336 laws restricting access to abortion. Forty-four percent of these were enacted in the past decade. As a result, the overall number of facilities providing abortions in the United States is steadily declining. Prior to the Supreme Court's decision in Dobbs v. Jackson Women's Health Organization in 2022, 40% of reproductive-aged women resided in a county without an abortion provider, and 25 states had five or fewer abortion clinics. Since this decision, the number of states with no abortion clinics has increased, and the future of legal abortion access in many states is uncertain.

A recent report on the safety and quality of abortion care in the United States published by the National Academies of Sciences, Engineering, and Medicine concluded that although legal abortion is

both safe and effective, the likelihood that patients receive the type of abortion services that best meets their needs varies considerably depending on where they live. This is significant because lack of access to safe, legal abortion is the strongest risk factor for having an unsafe abortion procedure, which can result in severe maternal morbidity and mortality. In fact, in a survey of women living in Texas in 2012 after drastic cuts to family planning funding, 7% of women reported having attempted a self-induced abortion. This is significantly higher than the 2% of women who reported trying to end their pregnancy on their own in a national survey of abortion patients in the United States in 2008.

Clinicians whose patients are of reproductive age should be familiar with the legal abortion restrictions in their states. This knowledge is important for clinicians who refer patients to abortion providers, as well as clinicians who perform abortions. Being able to refer women promptly to an appropriate provider reduces harm by ensuring that patients get the care they need as soon as possible.

# Counseling Prior to Induced Abortion

Preoperative counseling includes a review of pregnancy options and thorough assessment of the patient's medical and surgical history. Options for medical or surgical management should be reviewed with the patient, including a discussion of risks, benefits, and alternatives to the planned procedure. Additionally, as in the case of miscarriage, the patient's support system, future fertility plans, and any contraceptive needs and desires should be reviewed and discussed. Some states have mandated the content of counseling. For instance, in the state of North Carolina, a patient must undergo phone counseling 72 hours prior to the start of any induced abortion procedure. The phone counseling content is dictated by the state's statute.

Some patients may want further information on resources available in the community for grief management. Patients may obtain these resources from a number of sources in the community including their church or family. For patients who do not have access

to such resources, clinicians can recommend online and telephone-based resources, such as Exhale Provoice.

Patients may desire contraception immediately after the induced abortion; all patients should be offered contraception. Intrauterine contraception and subdermal contraceptive implants can be placed immediately after the procedure. Women who desire hormonal contraceptives should start those contraceptives the day of or the day immediately following the abortion procedure. Contraception should be discussed with patients seeking abortion in a nonjudgmental manner. Some patients may prefer to wait and have their discussion about contraception with their primary physician.

First trimester induced abortion can be managed medically or surgically. Medication management of abortion is supported by evidence to be effective through 11 weeks. Surgical first trimester induced abortion can be undertaken by a uterine vacuum aspiration procedure in a clinic setting or in the operating room. The choice of location should ideally be based on the patient's desires for sedation and anesthesia, if not dictated by concomitant serious medical conditions. Unfortunately, state and funding restrictions may constrain these options.

# Preoperative Evaluation

The preoperative evaluation of a pregnant patient undergoing surgical management of first trimester induced abortion is similar to the preoperative evaluation for miscarriage.

Ultrasound is usually performed prior to first trimester uterine vacuum aspiration to confirm intrauterine pregnancy and gestational age. Ultrasound is necessary if there is discrepancy between estimated gestational age by last menstrual period and physical examination or if the size/position of the uterus is unclear.

Knowledge of the patient's hematocrit (or hemoglobin) and Rh type is important prior to induced abortion. Screening for chlamydia and gonorrhea should be targeted based on risk factors, symptoms, or examination.

# Prophylactic Medications for Vacuum Aspiration

Administration of prophylactic antibiotics is recommended prior to induced abortion to reduce risk of infection. A meta-analysis by Sawaya et al., in 1996, reported that administration of prophylactic antibiotics decreases the risk of postabortion infection by close to 50%. The specific antibiotic and the specific dose are less important than ensuring the antibiotic is received in a timely manner. The most commonly used regimens include preoperative doxycycline 100 mg (possibly with a second dose 12 hours after the procedure) and preoperative azithromycin 500 mg. Although there is a paucity of data, prophylactic antibiotics should also be considered when suction curettage is performed for miscarriage management.

# Surgical Uterine Vacuum Aspiration

## *Cervical Preparation*

Cervical preparation refers to the administration of cervical ripening agents or insertion of osmotic dilators within the cervix prior to a uterine vacuum aspiration procedure. Adequate cervical preparation decreases risks of uterine perforation and cervical laceration. Additionally, cervical dilation must be adequate to accommodate the correct cannula size to ensure complete evacuation of uterine products. Adequate cervical dilation prior to starting the procedure also can decrease procedure time and thus decrease patient discomfort. In contrast to induced abortion, cervical preparation may not be necessary in the surgical management of first trimester miscarriage, as the cervix may be dilated in such cases.

The type of cervical preparation and the length of time of the preparation vary by practitioner, patient, and clinical setting. Evidence supports that cervical preparation should be considered for patients at increased risk of complications from mechanical cervical dilation, including adolescents, providers with limited experience , and procedures performed late in the first trimester. To achieve cervical softening and minimize the extent of mechanical dilation

needed, 400 μg of misoprostol is administered buccally for at least 3 hours prior to the procedure. The use of osmotic dilators is not typically required for first trimester vacuum aspiration; this technique is described in later sections of this chapter (**TABLE 16.1**).

## TABLE 16.1
## Suggested Cervical Preparation Regimens for Aspiration and Dilation and Evacuation Procedures

| ESTIMATED GESTATIONAL AGE | CERVICAL PREPARATION |
|---|---|
| Up to 11W6D | Preparation may not be required; consider misoprostol 400 µg buccally, sublingually, or vaginal 3 hours prior to the procedure if the patient is<br>1. <20 y age<br>2. Nulliparous<br>3. No prior vaginal delivery |
| 12W0D-14W6D | Misoprostol 400 µg buccally 3 h prior to the procedure |
| 15W0D-16W6D | Osmotic dilators or misoprostol:<br>Osmotic dilators:<br>1. Dilapan-S (quantity: 1-2 for at least 4 h)<br>2. Laminaria (quantity: 1-3 for at least 4 h)<br>Misoprostol 400 µg buccally for at least 3 h prior to the procedure |
| 17W0D-19W6D | Osmotic dilators:<br>1. Dilapan-S (quantity: 2-5 for at least 4 h) PLUS laminaria (quantity 1 to facilitate removal of dilators)<br>2. Laminaria (quantity: 6-10 for usually overnight)<br>May add misoprostol 400 µg buccally for at least 3 h prior to the procedure; may require repeated doses (misoprostol alone for cervical preparation should be considered only by highly experienced surgeons) |
| >20W0D | May require a series of multiple sets of osmotic dilators, with or without mifepristone or misoprostol |

# *Pain Control*

Options for pain control include local anesthesia with a paracervical block (discussed in further detail below), minimal sedation plus oral anxiolytics and narcotics, moderate sedation, deep sedation, and general anesthesia. Moderate sedation with intravenous (IV) anxiolytic and narcotic medications has been shown to decrease procedural pain, although it may be associated with postoperative nausea and vomiting. Oral anxiolytics and narcotics are inferior to IV administration and may not provide additional benefit over paracervical block alone. Deep sedation and general anesthesia require administration by an anesthesia clinical specialist. General anesthesia is associated with an increased risk of hemorrhage, blood transfusion, and cervical laceration. On this basis, the World Health Organization Safe Abortion Guidelines recommend against routine use of general anesthesia for management of abortion. Plans for pain control during surgical abortion should be discussed during preoperative counseling and influenced by patient choice, with strong consideration given to the gestational age and expected length of the procedure.

# *Paracervical Block*

Prior to beginning the surgical procedure, a bimanual examination should be performed to assess the size and position of the uterus. A speculum is then placed for adequate visualization of the cervix and to provide uninhibited path for the dilators to enter the cervix. A speculum with standard length blades may limit the descent of the cervix with traction, thereby making the procedure more difficult. Some clinicians, therefore, prefer a speculum with shorter blades, such as the commercially available Moore or Klopfer modifications of the Graves speculum. These have 1-inch shorter blades and standard width.

Local anesthesia for vacuum aspiration is achieved with a paracervical block (**FIG. 16.1**). Lidocaine, in concentrations of 1% or 0.5%, is frequently used. The total dose of lidocaine should not

exceed 5 mg/kg or 200 mg, whichever is less. Some clinicians use a lidocaine solution buffered with sodium bicarbonate to decrease discomfort. While techniques vary among providers, the cervix is usually first infiltrated at the 12-o'clock position (for application of the tenaculum) followed by injection at two or more sites, over 30-60 seconds, at a depth of 1.5-3 cm, at the junction of the cervix and vagina (see **FIG. 16.1**).

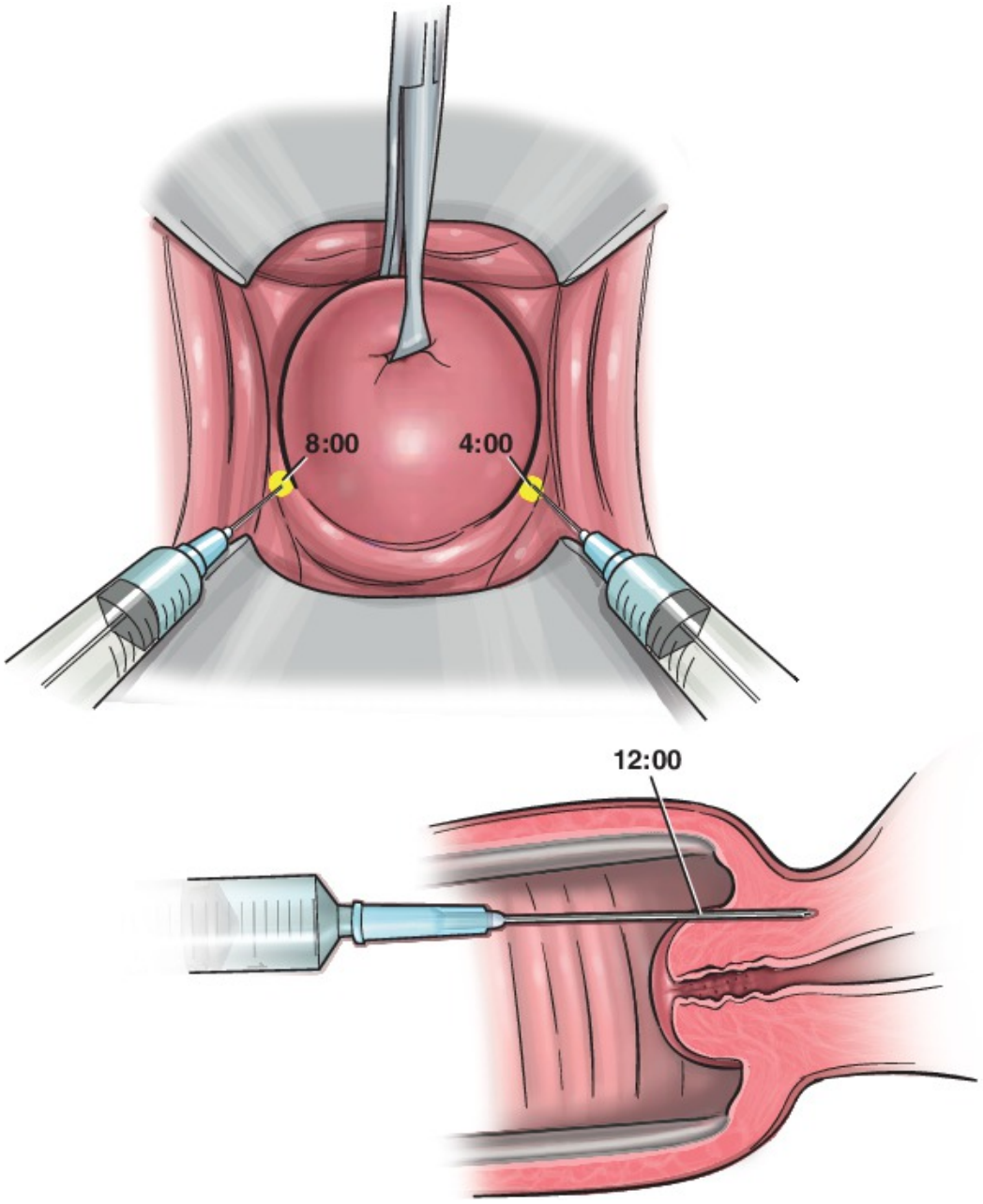


**FIGURE 16.1** Paracervical block. The first injection is 1-2 mL at 12o'clock on the cervix, prior to placing the tenaculum. At leasttwo other locations are also injected. The anesthetic should be administered laterally about 1.5-3 cm deep to flood the uterine vessels and nerve plexus.

## *Tenaculum Placement*

Traction on the cervix with a tenaculum during uterine vacuum aspiration stabilizes the uterus and straightens the angle between the cervix and corpus, which should reduce the risk of perforation. The tenaculum should have a firm purchase on the cervix. Some clinicians prefer an atraumatic tenaculum to reduce the risk of cervical laceration, although these may slip off more readily than the single-toothed variety. If the puncture site on the cervix bleeds after tenaculum removal, direct pressure nearly always stops the bleeding. Silver nitrate or Monsel's solution (ferric subsulfate) can be used if pressure does not achieve hemostasis.

The method of tenaculum placement should be based on clinician preference and skill. High vertical placement at the 12 o'clock position, with one tooth in the canal and one on the anterior cervix, almost eliminates the risk of the tenaculum tearing through during dilation. However, a superficial horizontal application of the tenaculum is less likely to obscure the vision and movement of instruments. If the uterus is retroverted, some clinicians prefer to place the tenaculum on the cervix at the 6 o'clock position (**FIG. 16.2**).

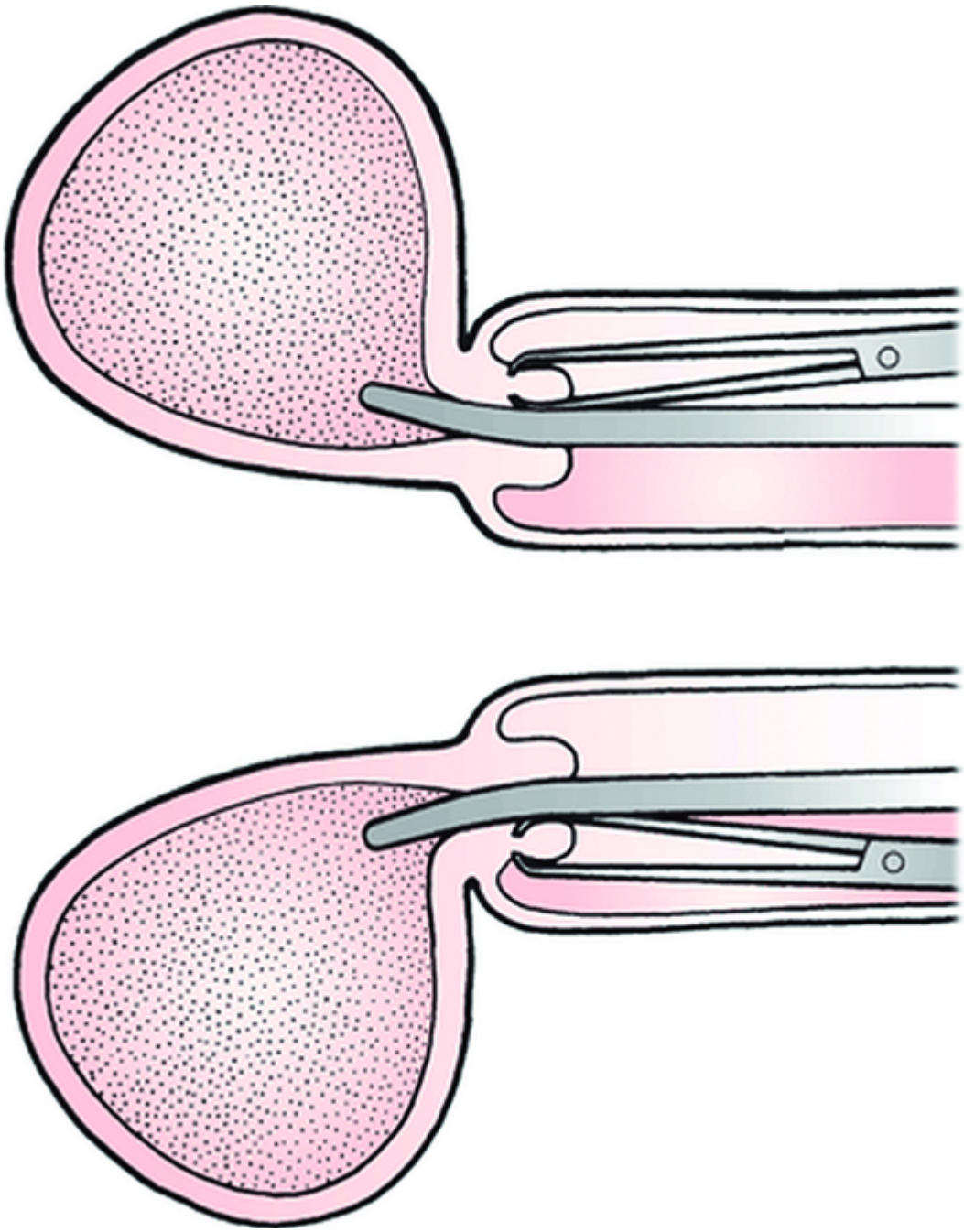


**FIGURE 16.2** Traction on the cervix during dilation. *Top*: Tenaculum placed vertically on the anterior lip. *Bottom*: Tenaculum placed vertically on the posterior lip for a retroverted

uterus. Note the posterior direction of the dilator in the retroverted uterus.

## *Ultrasound Guidance*

Ultrasound imaging during the procedure can be helpful in an educational setting, as well as in patients with uterine abnormalities (such as leiomyomata). Data are limited to recommend routine ultrasound guidance for first trimester uterine vacuum aspiration.

## *Mechanical Cervical Dilation*

Mechanical cervical dilation and all subsequent steps of the procedure should employ a “no-touch” technique. This technique ensures that the tips of the instruments entering the uterine cavity remain sterile (to reduce infection risk). Principles include the following:

- Gather all needed materials before placing the speculum.
- Hold only the center of dilators and avoid touching the tips.
- Attach the sterile cannula to the vacuum source without touching the cannula tip.
- Avoid vaginal contamination of uterine instruments.
- Change instruments that will enter the uterus if inadvertently contaminated.

Sounding the uterine cavity before the procedure is not recommended. This step increases the risk of perforation and should be avoided.

The cervix will need to be adequately dilated to accommodate the suction cannula. Dilation should be performed to a diameter that allows insertion and rotation of the desired cannula. The appropriate cannula size is determined largely by the size of the uterus. In general, the diameter of the cannula, in millimeters, should be equal to the estimated weeks of gestation, plus or minus 1 week. For example, an 8-mm cannula may be adequate for evacuating a pregnancy of 9 weeks’ gestation. More experienced clinicians prefer

a smaller cannula; the clinician must weigh the advantage of needing less dilation against the potential disadvantages of longer operating time and an increased risk of incomplete abortion. The most frequently used cannulas in the United States are clear plastic, with a slight angulation, and are either rigid or flexible (**FIG. 16.3**).

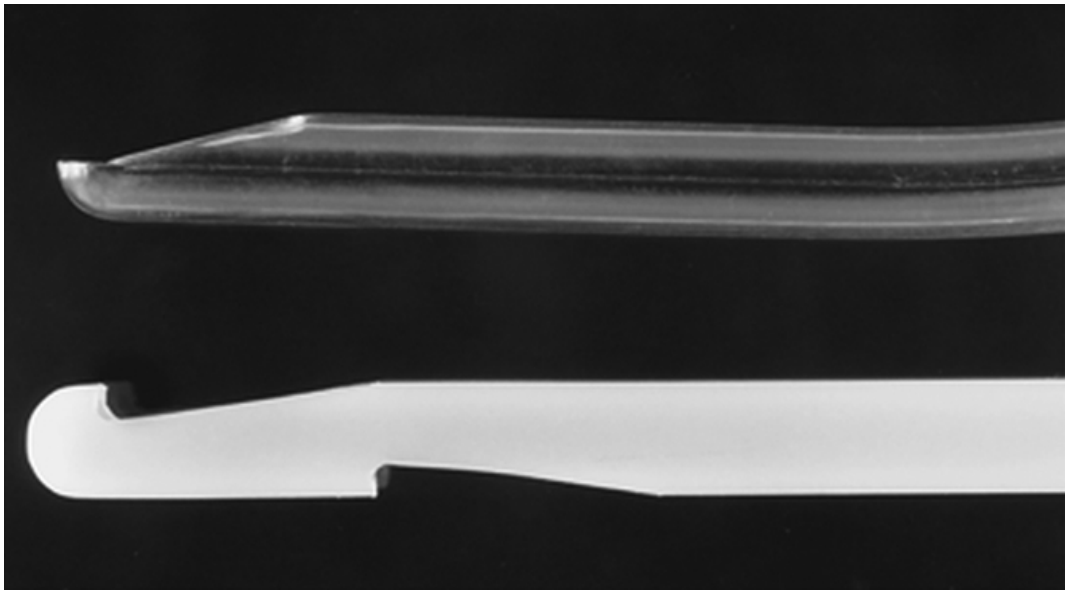


**FIGURE 16.3** Comparison of rigid (*top*) and flexible (*bottom*) curette tips.

Mechanical dilation can be accomplished with Pratt dilators, which are measured in French (F) units or mm of circumference. To determine the cannula size (in mm) corresponding to the Pratt dilator size (in French), the dilator size (in French) is divided by pi or ~3. For example, an 8-mm cannula would require dilation with Pratt dilators to 25 F (Pratt dilators only have odd measurements). If cervical preparation has been initiated prior to starting the procedure, the mechanical dilation required is minimal.

To dilate the cervix, the clinician should hold the center of the Pratt dilator between the thumb and index finger. The other fingers can remain extended to prevent plunging into the uterus in case of sudden loss of resistance. Dilation can start with the smallest size that will pass easily, even if not the smallest in the set (eg, 17 F

instead of 13 or 15 F); this may reduce the risk of perforating the uterus or creating a false passage.

Occasionally, the cervix may be difficult to dilate. If excess force is necessary to pass the Pratt dilator through the cervix, the clinician should stop and reassess, rather than risk injuring the cervix with forceful dilation. When appropriate, one option is to use a smaller cannula than originally planned, limiting the extent of dilation required. Alternatively, the clinician can insert one or more osmotic dilators into the cervix and/or administer buccal, sublingual, or vaginal misoprostol and complete the operation several hours later, by which time adequate dilation will have been achieved.

## *Uterine Vacuum Aspiration*

Uterine vacuum aspiration involves dilation of the cervix, followed by either manual vacuum aspiration (MVA) or electric vacuum aspiration (EVA). These are the most common techniques used for both induced abortion and surgical management of early pregnancy loss. With MVA, a self-locking syringe (50-60 mL) is used as a source of suction (**FIG. 16.4**), while EVA utilizes tubing attached to an electric suction machine. MVA is as safe and effective as electric vacuum through 10 weeks of gestation. There are some minor differences between the two instruments, and they will be highlighted in this section. The remaining steps in the uterine vacuum aspiration procedures are the same (**BOX 16.1**).

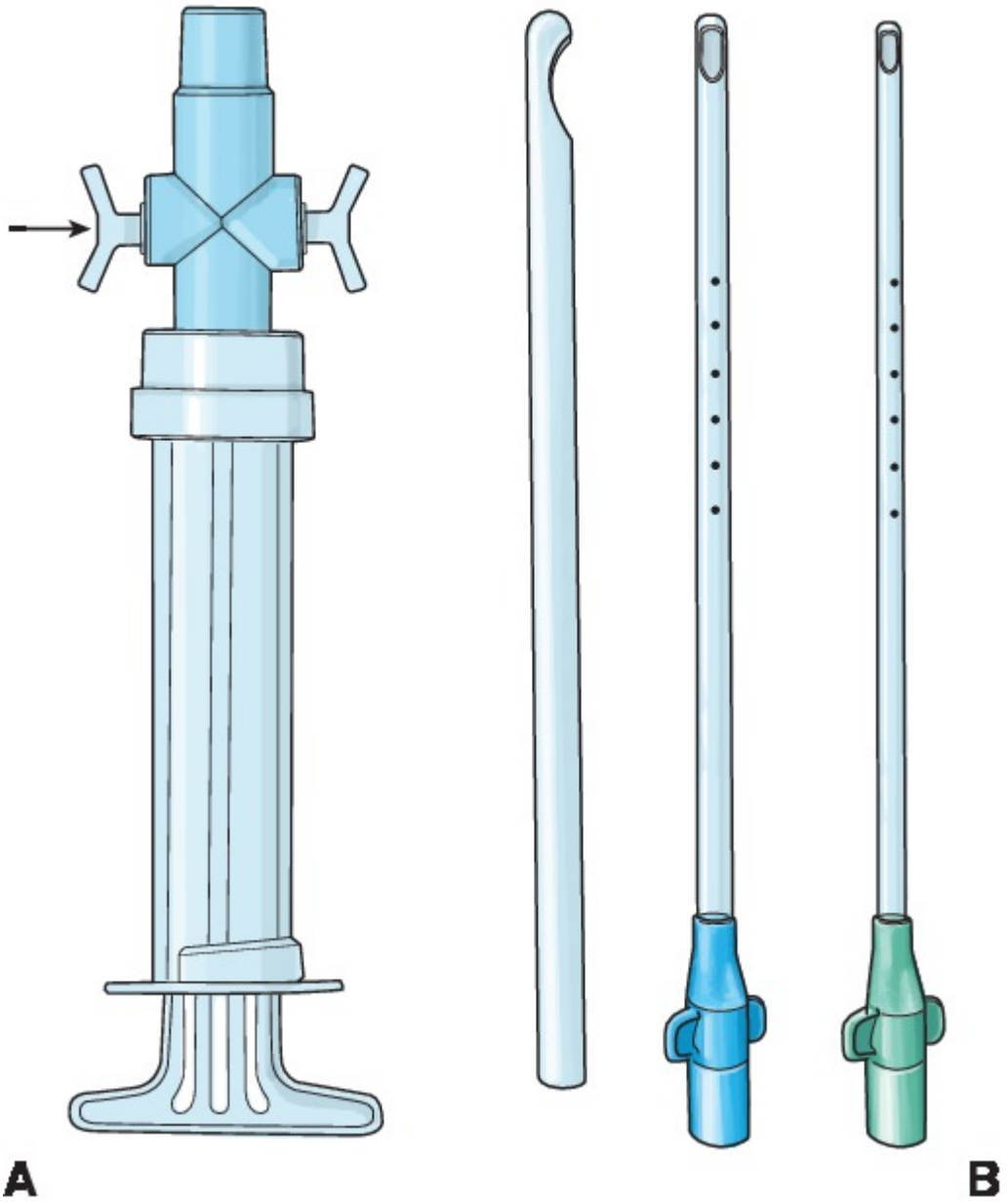



**FIGURE 16.4** **A.** Manual vacuum aspiration syringe. The *arrow* indicates the "pinch valves" on the syringe, which control the vacuum. **B.** Examples of different cannula sizes, from 12 mm (*leftmost*) to 6 mm (*right*).

# BOX 16.1 STEPS IN THE PROCEDURE

## Uterine Vacuum Aspiration

- Provide preoperative cervical preparation, if indicated.
- Administer prophylactic antibiotics if induced abortion. Antibiotics are not routinely recommended for surgical management of miscarriage.
- The patient should empty her bladder prior to the procedure.
- Analgesia and sedation should be administered as planned with the patient.
- After positioning the patient in dorsal lithotomy position, a bimanual examination should be performed.
- Insert the speculum and apply antiseptic to the cervix.
- Apply the tenaculum to the cervix and administer a paracervical block.
- Gently perform cervical dilation as appropriate for gestational age and chosen cannula size. Use the no-touch technique for dilation as well as the remaining steps.
- Gently insert the suction cannula, attach syringe or suction tubing, and apply suction. Gently begin repetitive rotary and in and out motions to evacuate tissue.
- Limit the number of passes through the cervix.
- The procedure is complete when the endometrium has a gritty feel in all quadrants, no further tissue is evacuated, and pink foamy bubbles appear in the cannula.
- Remove the tenaculum and assess for hemostasis.
- Examine the aspirate and ensure it correlates with expected findings for gestational age.

Manual Vacuum Aspiration

The equipment used for MVA is portable, inexpensive, and convenient for outpatient use. Studies have demonstrated the safety, acceptability, and cost-effectiveness of MVA for surgical management of early pregnancy loss. This procedure lends itself to in-office procedures for low-risk patients. As with other in-office procedures, office MVA is most appropriate for patients who are clinically stable and without multiple comorbidities. Clinicians who are contemplating provision of in-office MVA may be more comfortable initially offering it to patients with incomplete abortion or at an early gestational age and then increasing the range as their comfort level allows (FIG 16.4).

When using the MVA, the clinician attaches the syringe to the cannula and inserts the cannula into the uterine cavity. Then the clinician releases the pinch valves to activate suction in the uterine cavity. Uterine vacuum aspiration involves rotary and in-and-out cannula movement, allowing blood and tissue to flow into the syringe. As the procedure continues, the syringe fills and the suction decreases. Multiple passes may be needed, and the syringe should be emptied between passes. Advancing the plunger of the syringe while the cannula is connected and in the uterus must be avoided because an air embolism can result. The procedure continues until the endometrium feels gritty, and small bubbles appear in the syringe, indicating completion of the procedure. The operator will also feel the uterus contract down to a smaller size as it is emptied. The syringe and cannula are disposable, although, depending on the make and model, standard instructions are available for clinicians to disinfect the syringe and use it multiple times (**FIG 16.5**).

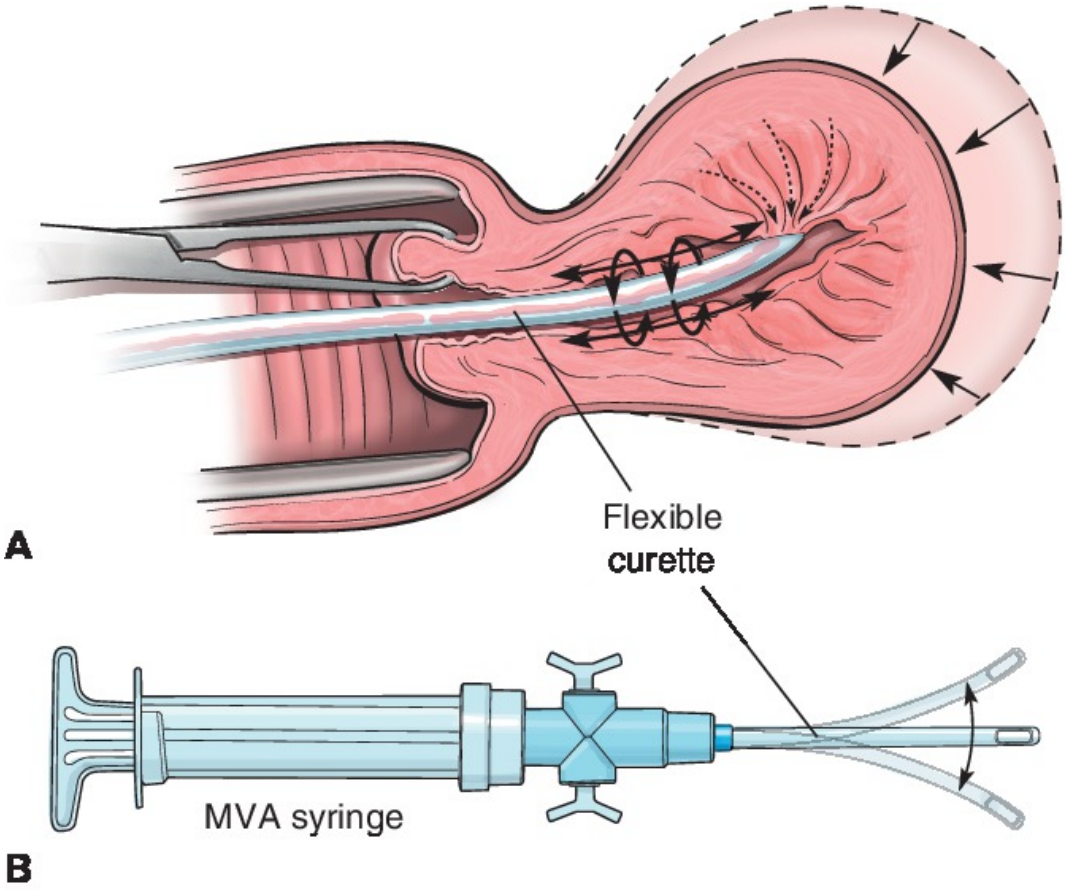



**FIGURE 16.5** Uterine vacuum aspiration. **A.** The flexible curette is usually inserted to the fundus and rotated, and then products are removed with rotating and back and forth movement. **B.** The uterus contracts around the cannula as products are aspirated.

## Electric Vacuum Aspiration

For EVA, plastic tubing with a swivel handle attaches to the cannula at one end and to the vacuum machine on the other. After the cannula has been inserted and the suction tubing connected, the clinician turns on the suction machine and aspirates the uterine contents with the cannula, using similar principles and technique to MVA. One of the principles of abortion technique is to operate in the

lower uterine segment. The fundal contents of the uterus are brought down by suction and the uterus involutes as it empties. This technique reduces the risk of perforation, retained products of conception, and hemorrhage.

## *Assessing Completion of the Procedure*

The flexible plastic cannula (see **FIG. 16.3**) suctions opposite sides of the cavity simultaneously and provides a gritty sensation when the uterine vacuum aspiration is complete; however, it can sometimes be difficult to appreciate this sensation with the rigid plastic cannula. Small bubbles will also appear in the suction tubing when the procedure is complete. Some clinicians use a sharp curette to check for completeness at the end of the procedure; however, routine use of the sharp curette is not necessary and may increase perforation risk. Ultrasound can help confirm an empty uterus. If there is doubt the procedure has been completed, a smaller size cannula can be used, allowing the uterine walls to further contract; this may assist identification of the gritty texture.

Completion of the procedure includes an examination of the aspirated tissue. This is to confirm the presence of an appropriate amount of fetal tissue, with a goal to exclude the possibility of an ectopic pregnancy or retained products of conception. Pregnancies of 10 weeks' gestation and later will have recognizable fetal parts. Identification of chorionic villi and membranes is essential for pregnancies earlier than 10 weeks' gestation. The aspirated tissue should be rinsed under tap water in a fine mesh strainer to remove blood and clots. A glass dish is useful for examining the tissue suspended in water. For early pregnancies, white vinegar (instead of water) may facilitate the recognition of villi. Backlighting from a horizontal x-ray viewing box is especially useful. Villi appear soft, fluffy, and feathery, with discernible fingerlike projections; in contrast, decidua appears coarse and shaggy (**FIG. 16.6**).

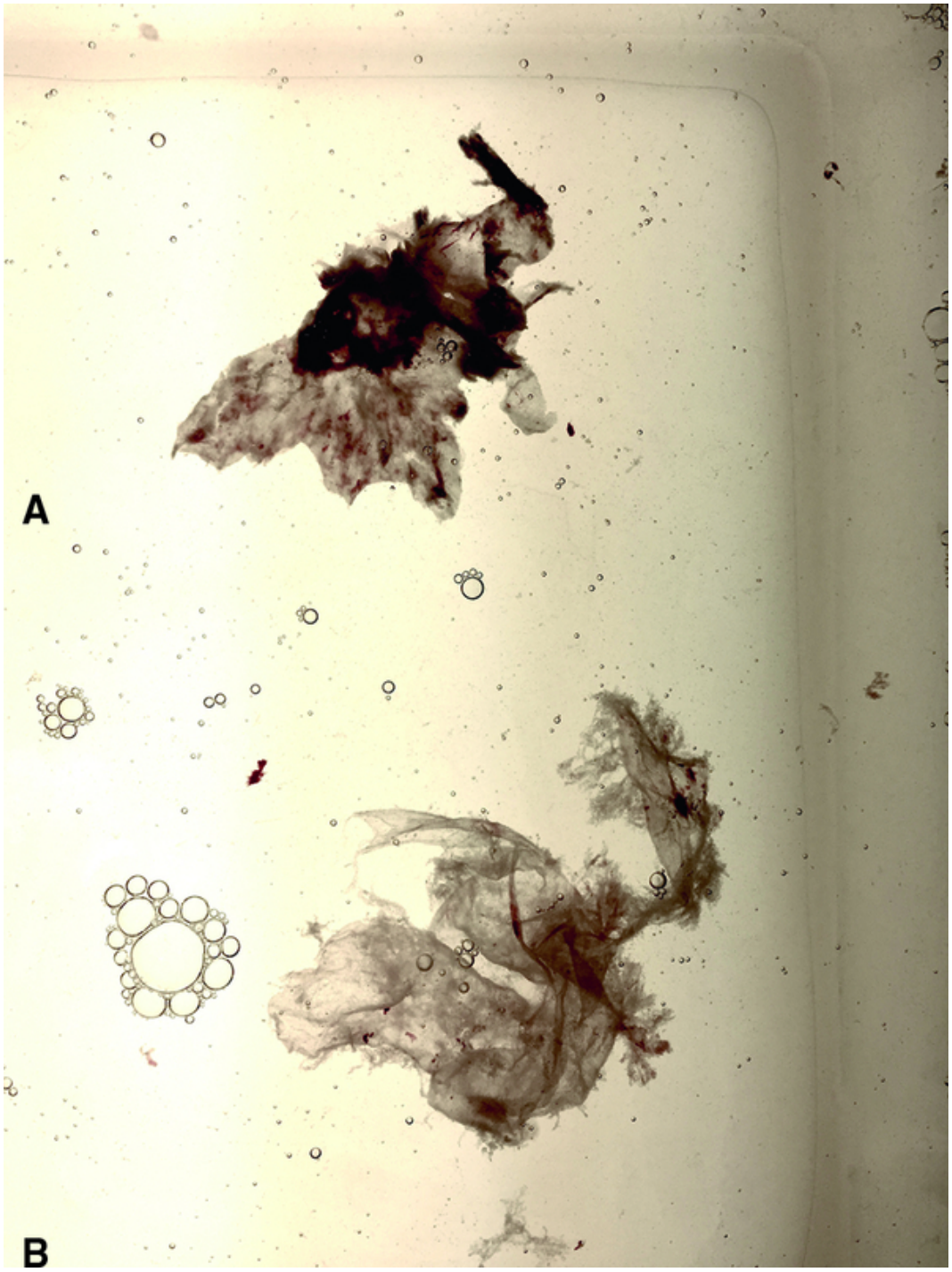



**FIGURE 16.6** A. Decidua and B. sac with villi following aspiration at early gestational age.

Failure to identify villi suggests several possibilities: failed attempted abortion, perforation with fetal tissue outside the uterus, very early gestational age, or ectopic pregnancy. The clinician must carefully evaluate these possibilities. If the clinician cannot identify villi and/or fetal parts in the aspirated tissue, they should reevaluate the patient, with special attention to the possibility of ectopic pregnancy. Ultrasound may show a retained intrauterine gestational sac or fetal parts, in which case repeat uterine vacuum aspiration (with or without ultrasound guidance) should be considered. If fetal tissue still cannot be identified after repeat aspiration and there is no evidence of ectopic pregnancy or retained products of conception on ultrasound, the clinician should consider measuring a serum quantitative β-hCG, with a repeat measure in 24-48 hours to ensure that it is appropriately decreasing.

Patients with uterine anomalies, such as a bicornuate uterus, have a higher risk of failed attempted abortion. The clinician may encounter difficulty getting the cannula into the horn containing the pregnancy; ultrasound guidance may be helpful. Although not routinely used, in this circumstance, the clinician can place a bent sound inside a flexible 8-mm plastic cannula as a stent or guide. With ultrasound guidance, the clinician then inserts the cannula into the cavity and removes the sound, connects the cannula to suction, and then aspirates the cavity. Rarely, hysterotomy may be needed if vacuum aspiration and medication abortion fail in the setting of müllerian or other anatomic anomalies.

# Medication Abortion

Early in pregnancy, medication abortion is an alternative to uterine vacuum aspiration. Studies have shown that it can be performed safely at home and is well tolerated and effective through 77 days gestation, with a failure rate that increases with advancing gestational age, but overall still remains low. In 2017, medication abortions accounted for 39% of all nonhospital abortions. The use of telemedicine for abortion can substantially reduce barriers to use.

Medication abortion is typically accomplished with a combination of mifepristone and misoprostol. The U.S. Food and Drug

Administration has approved mifepristone for this indication but imposed a Risk Evaluation and Management Strategy (REMS) to regulate how prescribers dispense these medications. A single oral dose of mifepristone 200 mg should be followed by 800 μg misoprostol 800 μg no more than 48 hours later. Misoprostol can be administered buccally, sublingually, or vaginally. When administered vaginally, the dose of misoprostol can be administered immediately after mifepristone. If taken buccally or sublingually, the patient should wait at least 24 hours to take the misoprostol. For medication abortions at 64-77 days, efficacy is significantly improved if a second dose of misoprostol 800 μg is taken 4 hours after the first. Patients undergoing medication abortion who do not experience uterine bleeding within 24-48 hours of receiving misoprostol should be evaluated for ectopic pregnancy or abortion failure.

Women are assessed 7-14 days later to ensure abortion completion. Follow-up can be completed in person or virtually. If done in person, an ultrasound can confirm passage of the pregnancy. If done virtually, completion is assessed by history and symptoms. Patients who complete virtual follow-up should take a urine pregnancy test 4 weeks postabortion to ensure that the abortion is complete.

Women who choose medication abortion should be advised of the possibility that uterine vacuum aspiration may be indicated in the event of an ongoing pregnancy or retained products. In the rare event of ongoing pregnancy after medication abortion, uterine vacuum aspiration is recommended because of the potential teratogenic effects of misoprostol.

Medical contraindications to medication abortion include bleeding disorders, anticoagulant use, inherited porphyria, chronic adrenal insufficiency, long-term systemic corticosteroid use, or IUD in place (IUD should be removed prior to medication abortion). Women with anemia should be evaluated for symptoms, and plans made based on risks and benefits and shared decision-making. Laboratory tests include hematocrit (or hemoglobin) and Rh type. Ultrasound is a routine component of early medication abortions in most settings. Prior to medication abortion, the clinician should confirm that the patient will be able to follow up in the planned time frame for

ultrasound, serum beta-hCG, or urine pregnancy test to confirm completion.

During medication abortion, many patients report painful cramping, as well as unpleasant side effects from misoprostol, such as nausea, diarrhea, and fever. Nonsteroidal anti-inflammatory drugs, antiemetics, and antidiarrheals are typically prescribed to decrease associated side effects. Narcotics may also be prescribed for additional pain relief but should be administered with caution, at the lowest dose, and for the shortest amount of time necessary.

When mifepristone is not available, medication abortion can be achieved with misoprostol alone. However, multiple doses are usually required, prolonging the misoprostol side effects. The recommended regimen through 9 weeks' gestation is three doses of 800 μg each, 3-12 hours apart, administered vaginally, sublingually, or buccally. Success rates with multiple doses approach 93%.

# SURGICAL MANAGEMENT OF SECOND TRIMESTER PREGNANCY LOSS AND INDUCED ABORTION

## Epidemiology

According to the United States Centers for Disease Control and Prevention, in 2016, 10.4% of induced abortions in the United States were performed between 13 and 20 weeks' gestation. Only 1.3% of induced abortions were performed for gestations ≥21 weeks.

Patients who obtain second trimester induced abortions are more likely to be delayed because they did not suspect they were pregnant or because of logistical delays, such as difficulty locating a provider, arranging transportation, or initially being referred elsewhere. Many states have placed upper gestational age limits on abortion that restrict access, requiring patients to travel to another state in order to obtain an abortion. Second trimester induced abortions may also be performed for maternal or fetal indications. For instance, patients may seek second trimester abortion in

response to diagnosis of fetal anomalies on an ultrasound scan or presentation with previable preterm rupture of membranes.

## Counseling and Management Options

Between 14 and 24 weeks, dilation and evacuation is the most frequently used method for uterine evacuation in the United States (**BOX 16.2**). Labor induction methods offer an alternative, but in the hands of experienced clinicians, dilation and evacuation is safer, with lower risks of infection and blood transfusion. Some patients may desire to hold their fetus after the uterine evacuation. If this is the case, then labor induction may be preferred. Compared to labor induction abortion, dilation and evacuation is also associated with decreased risk for additional surgery (eg, for retained products). The details of labor induction are beyond the scope of this surgical textbook.

### BOX 16.2 STEPS IN THE PROCEDURE

#### Dilation and Evacuation

- Provide preoperative cervical preparation with osmotic dilators or medically (using misoprostol and/or mifepristone).
- Prophylactic antibiotics should be administered prior to induced abortion procedures.
- Analgesia and sedation should be administered as planned with the patient.
- The patient should empty her bladder prior to the procedure.
- After positioning the patient in dorsal lithotomy position, remove cervical dilators if present, and ensure the number removed correlates with the number placed.
- Perform bimanual examination and assess the cervix for adequate dilation.

- Insert the speculum, place the tenaculum (or ring forceps) on the anterior lip of the cervix, and administer paracervical block with vasopressin.
- Perform mechanical dilation if needed.
- Insert the cannula (generally 12, 14, or 16 mm), attach to suction apparatus, and drain amniotic fluid.
- Insert forceps (under ultrasound guidance if preferred) and remove tissue. Evacuation should occur from the lower uterine segment whenever possible and in as few passes as possible through the cervix to minimize risk of perforation and cervical trauma.
- Complete evacuation with one pass of the cannula with suction.
- Examine the tissue to confirm complete removal of all fetal parts.
- Ensure hemostasis, and remove the tenaculum/ring forceps and speculum.

Hysterotomy is an alternative for abortion but should be used only when usual surgical and medical approaches fail. Planned hysterectomy is appropriate in rare cases, such as when the patient does not desire future fertility and when preexisting pathology (such as large leiomyomata or carcinoma *in situ* of the cervix) justifies hysterectomy. Counseling regarding loss of future fertility and increased risk of complications should accompany any decision to perform a gravid hysterectomy for abortion.

# Pre-procedure Medications and Preparation

## *Antibiotics*

As previously noted, prophylactic antibiotics should be a routine part of induced abortion procedures.

# *Venous Thromboembolism Prophylaxis*

No studies specifically address venous thromboembolism (VTE) associated with surgical management of induced abortion or pregnancy loss. A systematic review by the Society of Gynecologic Surgeons concluded that, other than early ambulation, no prophylaxis is required for minor surgeries in patients without significant risk factors for VTE. However, patients having minor surgery who have two or more risk factors for VTE (eg, previous VTE, thrombophilia, malignancy) are at moderate risk. In these cases, prophylaxis is achieved by placement of intermittent compression devices, with the addition of heparin if the risk is particularly high. These recommendations can be applied to the management of patients seeking abortion who would be managed in an operating room.

# *Fasting*

Preprocedural fasting recommendations are highly variable and often set by the individual institution. In 2013, Wiebe et al. stated that fasting is probably unnecessary prior to abortion procedures before 18 weeks gestation using IV analgesia and sedation, assuming the patient will be responsive to verbal commands. The risk of respiratory aspiration is estimated to be 0.00006%. However, some institutions recommend fasting from solid intake for 6 hours prior to a procedure and from clear liquids for 2 hours prior to the procedure.

# *Management of Pain and Anxiety*

Options for pain management include no sedation or anesthesia, local anesthesia with a paracervical block, physician-administered sedation and analgesia, or deep sedation (general anesthesia) under the care of an anesthesia clinical specialist. Plans for pain control during dilation and evacuation should be discussed during preoperative counseling and influenced by patient choice, with strong consideration given to the gestational age and expected length of the procedure.

Local anesthesia for dilation and evacuation is achieved with a paracervical block. This procedure was described earlier in the chapter (see **FIG. 16.1**).

Intravenous moderate sedation with anxiolytic and narcotic medications has been shown to decrease procedural pain, although it may be associated with postoperative nausea and vomiting.

Some patients may choose, or require, monitored anesthesia care with deep sedation. General anesthesia is associated with an increased risk of hemorrhage, blood transfusion, and cervical laceration. Therefore, the World Health Organization Safe Abortion Guidelines recommend against routine use of general anesthesia for management of abortion. Adequate preoperative counseling can improve satisfaction with IV moderate sedation.

## *Preparation to Minimize Blood Loss*

Hemorrhage is the most common complication of dilation and evacuation. This risk increases with gestational age, affecting 6.3% of procedures performed after 18 weeks, gestation. Administration of vasopressin with paracervical block significantly decreases blood loss with dilation and evacuation, and its routine use is recommended by the Society of Family Planning. Four units of vasopressin (0.2 mL) mixed with the local paracervical block anesthetic lowers blood loss significantly. In one randomized study, vasopressin lowered the risk of a hemorrhage of 500 mL or more by fourfold.

In an attempt to decrease blood loss with second trimester uterine evacuation, although there is limited evidence, some clinicians routinely administer prophylactic misoprostol, methylergonovine maleate (Methergine), or oxytocin. A dose of 400 µg of misoprostol, when studied alone or with osmotic dilators for preoperative cervical preparation in the second trimester, was found to have little to no effect on blood loss. One randomized trial found that administration of oxytocin during dilation and evacuation procedures after 18 weeks' gestation was helpful for preventing excess blood loss.

## *Contraceptive Counseling at the Time of Abortion*

Fertility can return as soon as 7-10 days postabortion. Counseling on and provision of contraception at the time of abortion may be helpful to some patients; however, several studies have shown that as many as half of patients prefer not to discuss contraception at the time of abortion. Employing a patient-centered, shared decision-making model for contraceptive counseling at the time of abortion is recommended to avoid contraceptive coercion. For patients who do want contraceptive counseling and provision at the time of abortion, multiple methods can be safely initiated at the time of medical or surgical abortion. Intrauterine devices can be placed at the time of surgical abortion or after medical abortion is complete. Contraceptive implants, injection, pills, patches, and rings can be initiated immediately after surgical or medical abortion. Patients should be made aware of the availability of contraceptive counseling at the time of abortion.

## *Placental Assessment Prior to Abortion*

Prior to uterine evacuation, patients seeking abortion at ≥14 weeks gestation with a scarred uterus (such as from prior cesarean or myomectomy) should be assessed for placenta accreta spectrum (PAS). PAS is associated with severe hemorrhage, which can result in multisystem organ failure, disseminated intravascular coagulation, admission to intensive care unit, hysterectomy, and even death. History of previous cesarean delivery and the presence of placenta previa and/or a placenta overlying the incision site significantly increases the risk of PAS. The greater the number of previous cesarean deliveries, the greater the risk. Patients with PAS or concern for PAS should be referred for hospital management where access to blood products, interventional radiologists, surgeons, and intensive care are available.

# Dilation and Evacuation Procedure

Dilation and evacuation involves mechanical cervical dilation, followed by evacuation of the fetus and placenta via a combination of forceps and suction. Dilation and evacuation differs from uterine aspiration in two principal ways: it requires wider cervical dilation and use of forceps. Rapid manual dilation to a large diameter can damage the cervix and lead to increased risk of uterine or cervical perforation. Hence, dilation and evacuation procedures beyond ~14 weeks gestation should use osmotic dilators, misoprostol, and/or mifepristone for cervical preparation. The steps of the dilation and evacuation procedure are described in sequence below.

## *Cervical Preparation*

Cervical preparation prior to second trimester dilation and evacuation is crucial. There is extensive evidence comparing different approaches to cervical preparation prior to dilation and evacuation. Examples of frequently used regimens are provided in TABLE 4.1. Adequate cervical dilation is important to reduce the risk of uterine perforation and other surgical complications of dilation and evacuation. Women younger than age 20 may benefit the most from preprocedural cervical preparation. Additional considerations when choosing a regimen include the presence of learners and the level of sedation to be used during the dilation and evacuation procedure.

The dilation and evacuation procedure starts with cervical preparation, which in some cases can take up to 48 hours. The timing will depend upon the gestational age and clinical setting. When counseling patients for induced abortion, it is important to emphasize that the uterine evacuation procedure has begun once osmotic dilators have been inserted and the dilation and evacuation must be subsequently completed. Thus, patients should be certain of their decision prior to initiation. Rarely, a patient changes their mind about abortion after initiation of cervical preparation. Although some patients have continued their pregnancies uneventfully after removal of dilators, others have developed infection, spontaneous abortion, or preterm delivery.

Osmotic dilators currently available in the United States include laminaria and Dilapan (Medicem Inc, Boston, MA) (**FIG. 16.7**).

Osmotic dilators can be used in an outpatient setting. Some facilities utilize a same-day protocol, in which dilators are placed several hours before the planned procedure, which is completed later that day. Alternatively, osmotic dilators can be placed the day prior to the procedure; patients can be safely sent home with osmotic dilators in place overnight. The use of osmotic dilators dramatically reduces the risk of cervical injury and uterine perforation.

**FIGURE 16.7** Osmotic cervical dilators (laminaria and Dilapan-S). **A.** Dilapan-S. **B.**8-mm laminaria. **C.**3-mm laminaria. (**B, C.** Courtesy of MedGyn Products.)

Laminaria are hygroscopic sticks of seaweed that dilate the cervix over several hours. The principal mechanism appears to be desiccation of the cervix, which results in expansion of the dilators as they absorb moisture. The swelling of the laminaria accomplishes gradual dilation of the cervix (**FIG. 16.8**). The desiccation of the

cervix also alters the ratio of collagen to ground substance, thus changing collagen cross-linkages. Additionally, laminaria may alter the elaboration, release, or degradation of uterine prostaglandins, causing the cervix to dilate in areas not in direct physical contact with the laminaria. Maximum dilation is achieved at 24 hours after placement. Laminaria are made of natural organic material; although concerns were historically raised about potential increased infection risk, studies show no increased risk of infection with their use.

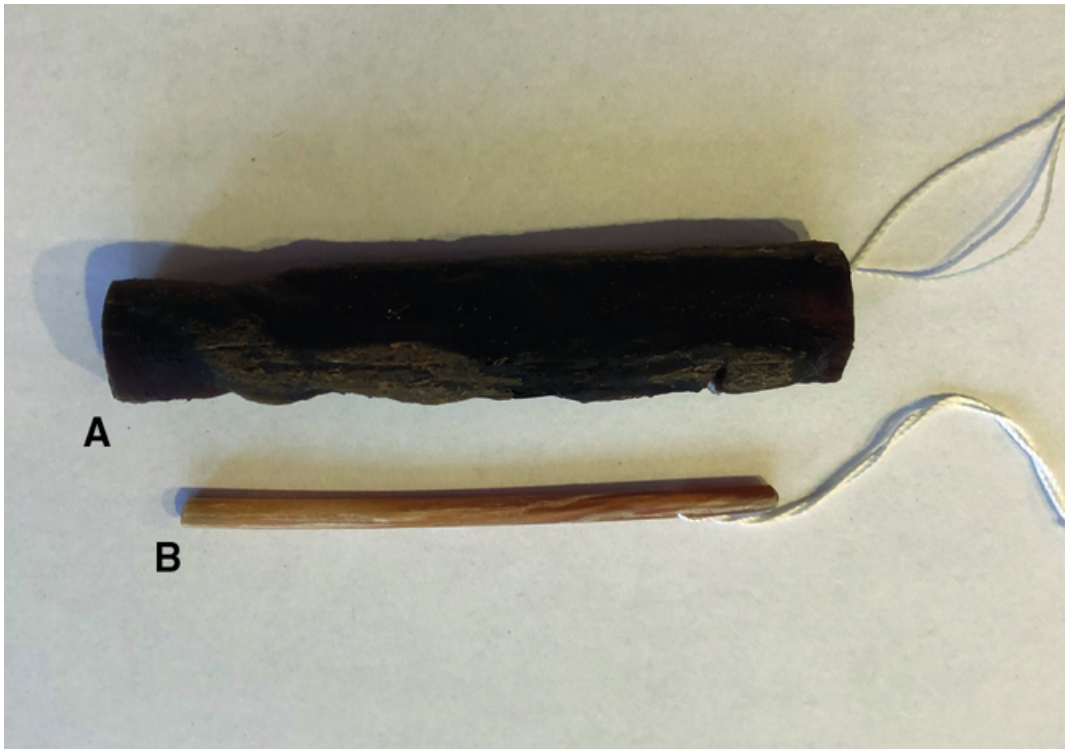



**FIGURE 16.8** Comparison of laminaria cervical dilators after expansion in the cervix **(A)** vs the appearance of the same dilator before placement into the cervix **(B)**. (Courtesy of MedGyn Products.)

Dilapan-S is a synthetic osmotic dilator, made of a polyacrylate-based proprietary hydrogel. This osmotic dilator is available in 3 and

4 mm diameters and lengths of 55 and 65 mm. Dilapan-S swells rapidly, demonstrating significant dilation by 2 hours. Most dilation is completed by 4-6 hours after placement, but expansion continues for up to 24 hours. Dilapan-S shortens as it expands, prompting a recommendation to choose the longer length. Adequate length is necessary to ensure dilation of the internal os and to prevent difficult removal.

Cervical preparation may also be accomplished medically, using misoprostol and/or mifepristone. These medications may be used alone, together, or as adjuvants to dilators. Misoprostol alone for cervical preparation may be a superb approach in the hands of surgeons with extensive and regular experience doing dilation and evacuation procedures. However, the decreased dilation achieved with misoprostol (compared to osmotic dilators), along with the contracted uterus as a consequence of the misoprostol, may make this approach to cervical preparation less desirable.

# *Return to Procedure Room (or Operating Room)*

Uterine evacuation is performed when cervical preparation is determined to be adequate. (Typically, the time for return to the procedure or operating room will have been set with the patient when osmotic dilators were placed.) Like all surgical procedures, standard safety checks should be completed first, such as confirming the patient's identity and correct procedure, as well as any patient allergies and relevant medical comorbidities.

The patient is then placed in the dorsal lithotomy position. A bimanual examination is performed to remove osmotic dilators (if present) and to assess cervical dilation and uterine position and size. Most clinicians prefer to use a bivalve speculum for uterine evacuation. The cervix should be cleansed with either povidone-iodine or chlorhexidine gluconate with 4% isopropyl alcohol. A paracervical block is administered as previously described (with 20 mL of 0.5% or 1.0% lidocaine, combined with vasopressin).

# *Tenaculum Placement*

The tenaculum must maintain its attachment through strong and steady traction in order to bring the cervix closer to the vaginal introitus, stabilize the uterus, and straighten the angle between the cervix and corpus. If the cervix is firm and not very dilated, many clinicians will prefer the use of a tenaculum. With a soft dilated cervix, an Allis or ring forceps may reduce the risk of cervical laceration. Cervical lacerations or bleeding puncture sites that are present after tenaculum removal can usually be easily treated with tamponade, a cauterizing agent (eg, silver nitrate or ferric subsulfate), or placement of one or two absorbable sutures.

# *Ultrasound Guidance*

Many clinicians routinely perform dilation and evacuation procedures under ultrasound guidance. In educational settings, use of ultrasound guidance is associated with a lower perforation rate and a reduction in operating time. When not employed routinely, ultrasound imaging should be readily available in facilities offering dilation and evacuation, and the clinician should have a low threshold for using it. Clinicians should strongly consider ultrasound guidance in patients with uterine abnormalities (such as leiomyomata) and when repeated insertion of forceps fails to grasp or remove fetal parts. However, when using ultrasound, it is important for clinicians to still pay attention to other important pieces of clinical information, such as the sensation of grasping tissue within the forceps blades and direct visualization of tissue emerging from the cervix.

# *Mechanical Cervical Dilation*

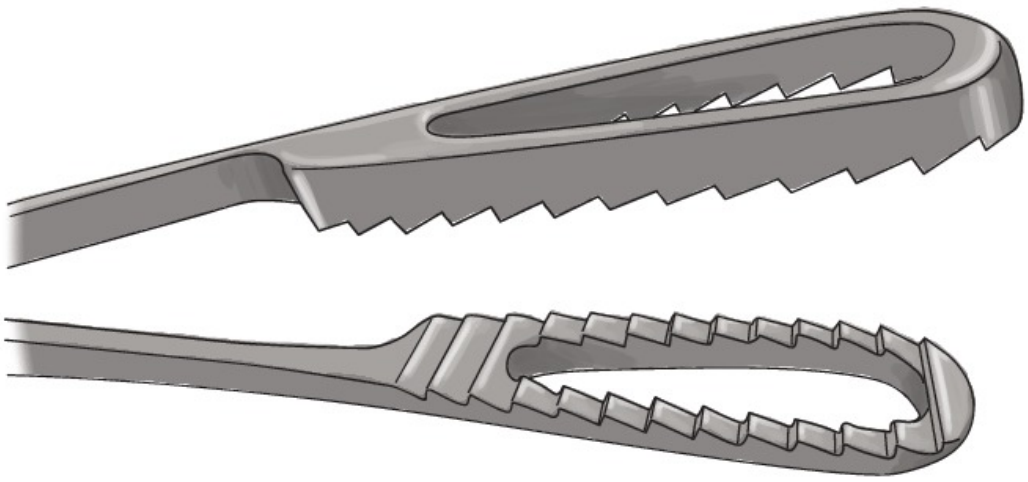
Adequate dilation of the cervix is required to decrease risk of perforation and cervical trauma during the procedure. Cervical dilation to 55 or 59 F may be required to place Bierer or Sopher forceps and to safely remove uterine contents without damaging the cervix. Occasionally, cervical preparation and mechanical dilation may be insufficient. The patient may need an additional period of

cervical ripening with either osmotic dilators or cervical ripening agent(s).

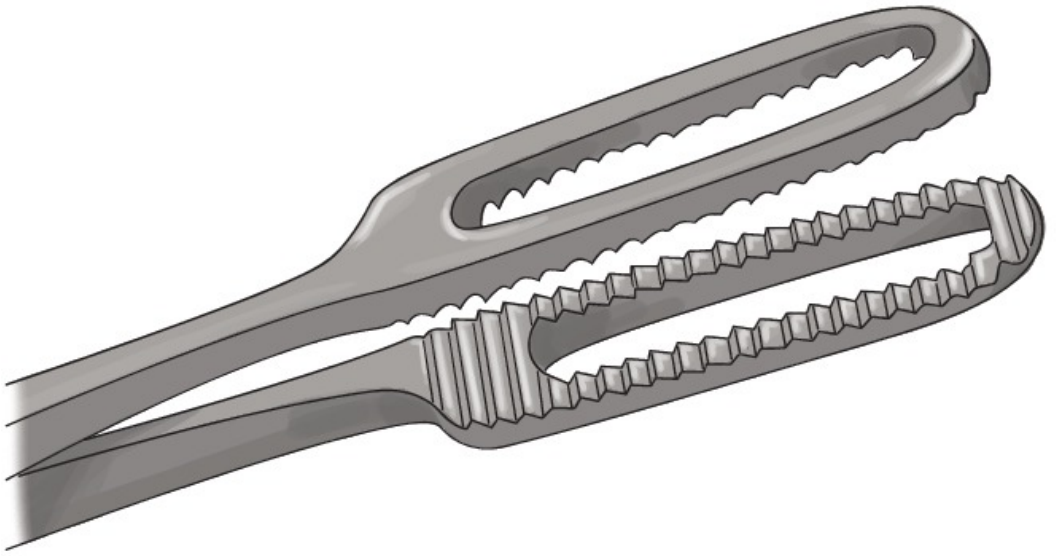
During mechanical dilation and the remaining steps of the evacuation procedure, the surgeon should use a “no-touch” technique (as described previously). This assures that the portions of instruments entering the uterine cavity remain sterile to minimize bacterial entry into the uterine cavity.

# *Evacuation*

Evacuation, or emptying the uterus, includes the use of suction aspiration and forceps. Suction is usually performed first, with the goal of draining amniotic fluid and drawing tissue into the lower uterus for forceps evacuation. The Bierer or Sopher forceps are used to extract tissue, as these are designed to cause minimal trauma to the surrounding endometrium. Bierer ovum and Sopher ovum forceps are fenestrated, serrated instruments designed to remove placental tissue and products of conception from the uterus. As with uterine vacuum aspiration, evacuation should occur from the lower uterus to minimize the risks of perforation. Some clinicians use the cannula with suction at the end of the procedure to confirm complete evacuation (**FIG. 16.9**).



**A**



B

**FIGURE 16.9** Jaws of Bierer forceps **(A)** and Sopher ovum forceps **(B)**.

If the uterine evacuation cannot be completed with ease, the clinician should interrupt the procedure. If the patient is hemodynamically stable, it is reasonable to temporarily discontinue the operation and administer misoprostol or oxytocin for 2-3 hours in the recovery room. After the woman returns to the operating room, the clinician usually finds the retained tissue at the internal os, from which is then easily removed.

## *Inspection of Products*

The clinician must confirm completion of the procedure by identifying all major fetal parts (four extremities, spine, and calvarium). Gentle exploration of the fundal and cornual areas with the forceps usually enables location and removal of any missing components. Intraoperative ultrasonography can also be helpful. If ultrasonography is not available, the clinician may be able to remove the speculum and insert one digit into the uterine cavity to locate residual material.

Some patients opt to have an intrauterine device (IUD) placed after abortion. This can be a highly effective way of ensuring contraception after abortion for those who are interested in this method of contraception. IUDs provide long-term, safe, and reversible contraception. An IUD can be placed at the fundus of the uterus under ultrasound guidance. Alternatively, an IUD can be placed without ultrasound after sounding the uterus to determine its depth. Spontaneous expulsion rates of IUDs after second trimester abortion are slightly higher than after first trimester abortion or IUD placement in a nonpregnant uterus.

# COMPLICATIONS OF SURGICAL ABORTION

Uterine vacuum aspiration and dilation and evacuation are associated with very low rates of morbidity and mortality. One important consideration is that the risk of complications for induced abortion increases as gestational age increases. Thus, abortion-related morbidity is decreased if patients have prompt access to induced abortion early in pregnancy.

## Immediate Complications

### *Hemorrhage*

Reported rates of hemorrhage vary, reflecting both diverse definitions (100-1000 mL blood loss) and imprecision in estimating volumes of blood loss. In large case series, the incidence of hemorrhage is 0.05%-4.9%. However, in a large multicenter study, the rate of blood transfusion associated with uterine vacuum aspiration (a better approximate of clinically significant hemorrhage) was only 0.06 per 100 abortions. For dilation and evacuation abortions performed later in pregnancy, investigators have reported hemorrhage and transfusion rates of up to 1% and 0.26%, respectively.

When hemorrhage occurs after uterine vacuum aspiration, the differential diagnosis includes uterine atony, cervical laceration, or uterine perforation. For uterine atony, treatment should include administration of uterotonic agents, draining the bladder, and manual compression. These measures are usually effective. Vasopressin can be injected intra- or paracervically. Methylergonovine maleate may be given (0.2 mg intramuscularly) as well as prostaglandins: carboprost 250 µg intramuscularly or misoprostol 1000 µg per rectum. Administration of oxytocin may be helpful in controlling hemorrhage after 20 weeks' gestation. Should bleeding persist, reassessment of the endometrial cavity by uterine vacuum aspiration, with ultrasound guidance, should be performed to rule out retained tissue. If the source of the bleeding is uncertain, a "cannula test" may be useful. The suction cannula is inserted into the uterus; bleeding through the cannula suggests an intrauterine source, such as atony, while bleeding around the cannula suggests a lower source, such as a cervical laceration. Occasionally, internal compression of the cavity by a large Foley catheter or a Bakri balloon can be helpful.

If these measures fail, uterine artery embolization may be considered, assuming the patient remains hemodynamically stable. This can often resolve bleeding, although effects on future fertility are unknown. Hysterectomy should be a last resort but may be indicated in cases of severe hemorrhage.

The possibility of disseminated intravascular coagulation (DIC) should be strongly considered in cases of excessive bleeding with no clear source. Immediate transfer to a center where blood transfusion and products can be administered should be initiated in suspected cases. DIC is rare but more frequent in cases of dilation and evacuation for fetal death (2% for fetal death, vs 0.2% for nonfetal death in a case series of 4428 procedures). DIC can also be seen in cases of amniotic fluid embolism, a rare but often fatal complication that occurs when amniotic fluid enters the maternal circulation.

Bleeding from placenta accreta may also lead to postabortion hemorrhage. With the increasing number of cesarean deliveries, the risk of encountering placenta accreta during abortion is increasing as well. In a series of more than 16 000 dilation and evacuation

abortions, the incidence of placenta accreta leading to hysterectomy was 4 per 10 000 cases.

## *Cervical Injury*

The most common type of cervical injury is a superficial laceration caused by the tenaculum tearing off during dilation. This can be easily repaired with running or interrupted sutures. Trauma from repeated passage of instruments or tissue may also cause injury to the cervical canal. More difficult to assess and repair are the cervicovaginal injury and the longitudinal laceration ascending to the level of the uterine vessels. Visible cervical lesions can be inspected and repaired vaginally if completely visualized. Placement of a Foley balloon may tamponade small cervical lacerations at the internal cervical os. Higher lacerations, when the full extent is not able to be assessed from the vaginal field, may require abdominal exploration and repair.

Rates of cervical injury range from 0.01 to 1.6 per 100 vacuum aspiration abortions and increase up to 3% for dilation and evacuation. Several risk factors for cervical injury during uterine vacuum aspiration have emerged. The use of laminaria and increasing clinician experience are associated with significantly lower risk. At earlier gestations, cervical preparation with misoprostol may confer similar benefits to laminaria. Use of general anesthesia may raise the risk of cervical injury, although study results have been mixed. Among factors beyond the control of the clinician, later gestational age, previous cesarean delivery, presence of müllerian anomalies, prior cervical conization, and age of 17 years or younger increase the risk.

## *Hematometra*

Acute hematometra, historically known as postabortal syndrome, occurs in 0.1%-1.0% of uterine vacuum aspiration abortions. Symptoms include severe cramping with or without rectal pressure, usually within 2 hours of the abortion procedure, and less vaginal bleeding than expected. The patient may be diaphoretic and her

uterus large and tender on examination. On ultrasound, the uterus is enlarged, and the endometrial cavity is distended, containing fluid consistent with blood. Treatment consists of prompt repeat uterine vacuum aspiration; usually, anesthesia and dilation are not necessary. Evacuation of the uterus leads to rapid resolution of symptoms. Administration of a prophylactic uterotonic, such as methylergonovine, after repeat evacuation can be considered, although the recurrence rate is very low. It is unknown whether routine administration of a prophylactic uterotonic prior to surgical abortion would reduce the incidence of acute hematometra.

## *Uterine Perforation*

Perforation is a potentially serious but infrequent complication of abortion. The incidence of perforation is about 0.9 per 1000 abortions. Risk factors for perforation include advancing gestational age and history of prior vaginal delivery, though the absolute risk remains low. Performance of uterine vacuum aspiration abortion by a less experienced clinician may increase the risk more than fivefold; cervical dilation by laminaria decreases the risk about fivefold. Ultrasound guidance, especially when used in a training setting, may reduce the risk of perforation.

The two principal dangers of perforation are hemorrhage and damage to the abdominal contents. Lateral perforations in the cervicoisthmic region are particularly hazardous due to proximity of the uterine vessels. Perforations of the fundus are more likely to be innocuous. Indeed, it is believed that most perforations are not suspected or detected. In a series of patients undergoing combined abortion and sterilization by laparoscopy, the investigators found a sixfold higher rate of uterine perforation than they had suspected clinically (20 vs 3 per 1000 abortions).

Most perforations do not require treatment. Many suspected or documented perforations require only observation, particularly if the patient is hemodynamically stable and there is no active bleeding. Recognized perforation with a dilator or sound is unlikely to damage abdominal contents. However, perforation with a suction cannula or forceps warrants further assessment, such as laparoscopy, to rule

out organ injury. If the clinician suspects a perforation, the uterine evacuation procedure should stop immediately. If an expanding retroperitoneal hematoma or injury to abdominal contents is suspected, prompt laparotomy should be considered. Laparoscopy can be useful in documenting perforation and assessing damage if the patient is stable. Additionally, the clinician can complete the abortion under direct visualization if necessary. Any patient with severe pain within hours after the abortion should be evaluated for possible perforation with bowel injury. If the perforation occurs before suction, the procedure can often be completed under either ultrasound or laparoscopic guidance with extra observation after the procedure.

# Delayed Complications

## *Retained Tissue*

The incidence of retained tissue after uterine vacuum aspiration abortion is <1%. Although retained tissue after abortion can pass without incident, it can also lead to hemorrhage, infection, or both. This complication usually manifests itself within several days of the abortion. Women present with cramping and bleeding and possibly fever. Measuring β-hCG levels are typically not helpful for diagnosis once an ongoing pregnancy has been ruled out. If clinical symptoms and ultrasound findings suggest need for reaspiration, it should be performed promptly. Antibiotics should be provided if there is evidence of infection. The thickness of the endometrium after successful abortion is variable. Thus, ultrasound findings alone, in the absence of clinical symptoms, should not automatically prompt the diagnosis of retained tissue.

## *Infection*

The likelihood of febrile morbidity is low after induced abortion. The incidence of fever of 38 °C or higher for 1 or more days is usually <1 per 100 abortions by uterine vacuum aspiration and 1.5 per 100 abortions by dilation and evacuation. Risk factors for infection

include untreated endocervical gonorrhea or chlamydial infection, as well as later gestational age at the time of abortion. Preoperative prophylactic antibiotics decrease the incidence of infection.

Postabortal infection can result from the procedure or from retained tissue. The organisms responsible for postabortal infection are similar to those responsible for other gynecologic infections. The cornerstones of therapy are administration of broad-spectrum antibiotics and uterine reaspiration if retained tissue is present. Infection or septic abortion may also be a rare complication of early pregnancy loss; in these cases, uterine evacuation of retained tissue is also a key component of management.

# Late Complications

## *Rh Sensitization*

Abortion is a potential cause of Rh sensitization for patients at risk. The likelihood of sensitization is low early in gestation and increases with advancing gestational age (and larger volumes of fetal erythrocytes). One study estimated the risk of Rh sensitization among Rh-negative patients following uterine vacuum aspiration abortion to be 2.6%. Thus, on a population level, the impact may be substantial.

Dosing of Rh immunoglobulin (RhIG) depends on gestational age at the time of abortion. Rh-negative patients should receive 50 μg of RhIG after first trimester abortion. The appropriate dose for abortions performed later in pregnancy is 300 μg.

## *Adverse Reproductive Outcomes*

Case reports and observational studies have linked induced abortion with adverse reproductive outcomes, such as intrauterine adhesions, infertility, preterm birth, low birth weight infants, spontaneous abortion, and ectopic pregnancy. Many published reports suffer from methodologic shortcomings. Most studies and systematic reviews have concluded that first trimester abortion (medication and vacuum aspiration) does not increase the risk for subsequent infertility,

ectopic pregnancy, cervical incompetence, or preterm birth in subsequent pregnancies.

In contrast, observational studies have suggested that sharp curettage and repeated suction curettage are associated with Asherman syndrome and with low birth weight in a subsequent pregnancy. A systematic review published in 2016 found a small, but statistically significant, increase in preterm birth in a subsequent pregnancy in patients who had a single first trimester uterine vacuum aspiration procedure, whether for miscarriage or termination of pregnancy. Further research is needed to determine if abortion is a significant risk factor for preterm birth.

## *Impact on Mental Health*

Multiple studies have shown that induced abortion does not negatively affect women's mental health. The Turnaway Study, a prospective longitudinal study that followed over 500 women for 5 years after having obtained or being denied an abortion, found that induced abortion does not increase women's risk of experiencing symptoms of posttraumatic stress, depression, or anxiety or of experiencing lower self-esteem or life satisfaction. Effects of being denied an abortion may be more detrimental to women's psychological well-being than allowing patients to obtain their wanted procedures.

## *Cancer*

Two large cohort studies have shown either no effect or a protective effect of induced abortion on subsequent breast cancer. Earlier findings of case-control studies suggesting a link between abortion and breast cancer have been discounted due to recall bias. Specifically, patients who have a history of an illness or complication (such as breast cancer) are more likely to recall and report their abortion than patients who are well.

## *Mortality*

Since 1972, when the Centers for Disease Control and Prevention began nationwide surveillance of abortion deaths, the safety of abortion has improved dramatically. In an extensive 2012 review, Raymond and Grimes found that the pregnancy-associated mortality rate for patients undergoing abortion was 0.6 maternal deaths per 100 000 legal abortions in the United States. Compared to 8.8 maternal deaths per 100 000 live births, this represents a 14-fold difference. The risk of death from abortion increases with increasing gestational age. As abortions performed at earlier gestational ages are safer, factors that influence a patient's ability to access legal abortion in a timely manner are medically relevant. In the United States, these include the number of trained clinicians, cost, and abortion restrictions.

Immediately after abortion became legal in 1973, abortion-related deaths declined, due in part to an increase in the skill of clinicians. Since then, abortion-related deaths have continued to decline because of improvement in the safety of abortion procedure techniques. For example, the practice of intrauterine instillation of hypertonic solutions to induce abortion has significantly decreased since the 1990s. Similarly, the routine use of general anesthesia for all surgical abortions has decreased. From 1998 to 2005, the main causes of death from abortion were hemorrhage, infection, and complications from anesthesia.

## ABORTION IN HIGHLY RESTRICTED SETTINGS

In resource-poor countries with highly restrictive abortion laws, unsafe abortion accounts for about 13% of all maternal deaths. A wide variety of unsafe abortion methods are used around the world. The two dominant approaches have been oral abortifacients and intrauterine instrumentation, such as injection of toxic substances or insertion of foreign objects. The most frequently reported complication of illegal abortion is retained products of conception, although the incidence of complications is unknown. Infection or septic abortion may also occur, as may hemorrhage. In settings

where elective abortion is illegal or highly restricted, the increased availability of misoprostol (sometimes informally or outside legal channels) has improved abortion safety. A national survey of U.S. abortion patients demonstrated that 2.6% reported using misoprostol or other substances for self-induction of abortion.

# KEY POINTS

- Management of miscarriage includes surgical, medical (with mifepristone and/or misoprostol), or expectant management. Early in pregnancy, uterine vacuum aspiration can be accomplished with a manual or an electric vacuum source. Patient preference should direct management plan in most cases.
- Medication abortion with mifepristone and misoprostol is a safe way to terminate early gestations through 11 weeks and 0/7 days. Patients can safely administer misoprostol at home. Thorough counseling increases patient's satisfaction and decreases complications. To be a candidate for medication abortion, patients must be able to understand the regimen, have access to emergency care if needed, and be able to follow up to ensure completion of the procedure.
- Uterine vacuum aspiration may safely be performed in an ambulatory setting.
- For most first trimester surgical abortions, cervical preparation prior to the procedure is not required. Patients younger than age 20 may benefit the most from preprocedural cervical preparation.
- Dilation and evacuation is generally safer and faster than labor induction for evacuation of second trimester pregnancies.
- Adequate preoperative cervical preparation is essential prior to dilation and evacuation. This can be achieved with osmotic dilators, mifepristone, and/or misoprostol.

- For second trimester dilation and evacuation, intraoperative ultrasound may decrease operative time as well as complications, especially in an educational setting. Special forceps are used to facilitate evacuation of later gestations.
- Prophylactic antibiotic use is indicated for surgical management of induced abortion.
- The use of vasopressin in the paracervical block decreases the risk of hemorrhage during dilation and evacuation.
- Pain control during an abortion procedure is essential. Anesthesia methods include paracervical block with or without sedation or general anesthesia. Risks and benefits of all options must be considered with respect to the patient's emotional and physical status.
- Complications of abortion include hemorrhage, cervical injury, uterine perforation, retained tissue, infection, anesthetic complications, and Rh sensitization. When performed in the hands of experienced clinicians, morbidity and mortality from abortion are rare.

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# CHAPTER 17

# SURGERY FOR BENIGN VULVAR CONDITIONS

Heather Z. Sankey and Ronald T. Burkman

**Vulvar Biopsy**
Punch Biopsy
Shave Biopsy
Excisional Biopsy
Biopsy Complications
Postoperative Management
**Surgery for Bartholin Gland Abscess and Cyst**
Incision and Drainage Using Word Catheter
Marsupialization
Excision
**Ablative Procedures**
Cryotherapy
Carbon Dioxide Laser
**Surgery for Vestibule Disorders**
Vestibulectomy
**Vulvar Necrotizing Soft Tissue Infections**
Debridement
**Labiaplasty**

Edge Resection Repair
Wedge Resection Repair
Postoperative Management
**Perineoplasty**
Revision Perineoplasty

The management of benign vulvar disease requires understanding of the diversity of possible benign lesions. This can be challenging due to the wide variety of lesions encountered. Vulvar lesions may be white, red, or hyperpigmented, plaquelike, patchy, papular, nodular, bullous, or erosive. This results in an extensive list of potential diagnoses that can challenge the gynecologist to make a correct diagnosis. In particular, it is important to differentiate benign lesions from preinvasive or invasive vulvar neoplasia. The use of an appropriate biopsy technique is essential to confirm the diagnosis when the diagnosis is unclear or the lesion persists despite treatment. In addition to diagnostic biopsy, gynecologists need to understand the surgical approaches used to manage infection or cysts of the vulva as well as the occasional acquired or congenital lesion.

# VULVAR BIOPSY

Vulvar biopsies are valuable as a diagnostic tool and can be effective for treatment of benign conditions. The term “vulvar biopsy” refers to the excision of skin and underlying dermis that generally is intended to sample a large lesion or remove a small lesion in its entirety. Vulvar biopsies may easily be performed in the outpatient setting under local anesthesia and should be readily performed whenever there is any concern for pathology based on examination or symptoms.

The most common indication for biopsy is to make a diagnosis of a growth or lesion particularly if it is suspicious for preinvasive or invasive disease. It is also indicated when a patient experiences

persistent symptoms that are not relieved with conservative measures in order to detect an underlying dermatosis or to confirm a diagnosis prior to treatment. Occasionally, benign lesions such as skin tags or actinic keratosis can cause irritation due to location along the underwear line, and these can be removed by an excisional biopsy. While many dermatoses such as lichen sclerosis have a classic clinical presentation, a biopsy is necessary to both confirm and document the dermatosis, to aid in treatment, and to exclude underlying malignancy (**TABLE 17.1**).

## TABLE 17.1
## Biopsy Indications

- A visible lesion that cannot definitively be diagnosed clinically
- A persistent lesion or ulcer that does not heal
- Vulvar symptoms with suspected vulvar dermatosis
- A symptomatic growth
- Any lesion that is increasing in size, changing color, or becoming irregular in shape raises concern for melanoma. Apply ABCDE evaluation of the lesion

**ABCDE Warning Sign**

**A**symmetry

Irregular **B**order

Variated **C**olor

**D**iameter >6 mm

**E**volving (growing or changing)

There are no contraindications to vulvar biopsy. These can be performed on women with bleeding disorders or patients who are on anticoagulation as long as the biopsies are not extensive. Women who are severely immunocompromised may need to have their biopsy delayed unless it is critical to their overall management.

Before beginning the biopsy procedure, one should ensure that all necessary materials and equipment are in the room. **TABLE 17.2** It is important to have an assistant in the room to pass equipment and to retract soft tissue as needed to enhance visualization. Local anesthetic agents with or without epinephrine may be used; the former will result in less bleeding and is safe to use on the vulva. There is no advantage to using a high concentration of local anesthetic. Sodium bicarbonate added to the local anesthetic agent in a 1:10 ratio can alleviate the burning sensation felt at the time of injection. Diluting the anesthetic with saline may also give some relief. Alternatively, a topical anesthetic cream can be applied to decrease the discomfort associated with injection of a local anesthetic. If there is an allergy to anesthetic agents, injection with saline alone has been shown to result in pain relief (**TABLES 17.3**).

## TABLE 17.2
## Supplies

**Necessary**

- Syringe for topical anesthetic. In some cases, a 1-mL tuberculin syringe may be sufficient
- 25- or 27-gauge needle (1″ or less)
- Sterile gauze (2″ × 2″ and 4″ × 4″)
- Antiseptic such as povidone-iodine or chlorhexidine
- Local anesthetic such as lidocaine 1% with epinephrine (TABLE 17.3)
- Biopsy instruments, for example, Keyes punches in various sizes, cervix biopsy forceps
- Sterile scissors and forceps
- Silver nitrate or Monsel solution
- Container for specimen
- Antibiotic ointment

**Optional**

- Needle driver and suture
- Scalpel

## TABLE 17.3
## Local Anethesia for Vulvar Procedures

| LOCAL ANESTHETIC AGENT | DOSE LIMIT | TOTAL DOSE | ONSET OF ACTION | DURATION OF EFFECT |
|---|---|---|---|---|
| Lidocaine 1% without epinephrine | 4 mg/kg | 300 mg (30 mL) | 2-5 min | 30 min to 2 h |
| Lidocaine 1% with epinephrine | 7 mg/kg | 500 mg (50 mL) | | Up to 3 h |
| Bupivacaine 0.25% without epinephrine | 2 mg/kg (0.8 mL/kg) | 175 mg (70 mL) | 5-10 min | Up to 6 h |
| Bupivacaine 0.25% with epinephrine | 3 mg/kg (1.2 mL/kg) | 225 mg (90 mL) | | Up to 6 h |
| Lidocaine 2.5% plus & Prilocaine 2.5% cream | | 5-10 g (thick layer) | 5-10 min on mucous membranes; 1 h for intact skin | 15-20 min for mucous membranes; 2-3 h for intact skin |

The biopsy approach should be based on the lesion location and type (see **TABLE 17.4**), equipment available, and experience with different techniques. The vulva should be closely inspected to accurately localize the most suspicious area. The choice of biopsy

site should take into consideration the angle of approach and the specific anatomy of the patient. An optimal tissue sample will include some normal tissue along with the area that appears most abnormal, particularly for ulcerated lesions, unless the entire lesion will be removed. At times, more than one site will require biopsy. Prophylactic antibiotics are not indicated. Cleanse the area with antiseptic and inject local anesthetic subcutaneously, creating a wheal under the area to be biopsied. Steps for performing vulvar biopsy are listed in **BOX 17.1**.

## TABLE 17.4
## Vulvar Biopsy Techniques

| TYPE OF BIOPSY | INDICATION |
|---|---|
| Punch biopsy | Most lesions, including inflammatory, except for suspected melanoma |
| Shave biopsy | Raised tumors; lesions that do not require full thickness for diagnosis |
| Excision | Melanoma, treatment of vulvar intraepithelial neoplasia |

## BOX 17.1 STEPS IN THE PROCEDURE

### Vulvar Biopsy

- Ensure supplies and equipment are in the room.
- Examine the vulva to choose biopsy site.
- Choose method of biopsy: Keyes punch, shave, or excisional biopsy.
- Cleanse the area with antiseptic.
- Administer local anesthetic subcutaneously.

- Perform biopsy removing only epidermis and dermis.
- Obtain hemostasis with pressure, Monsel solution, or silver nitrate.
- If necessary, suture with 4-0 absorbable suture.
- Cover the incision with antibiotic ointment and 2″ × 2″ gauze.

## Punch Biopsy

The traditional method for vulvar biopsy utilizes either a disposable or reusable Keyes punch biopsy. These are available in different size tips ranging from 1.5 mm in diameter to 8.0 mm in diameter. It is important to place tension on the tissue around the biopsy site with the nondominant hand, pulling the skin taut. The Keyes punch is then positioned, and gentle pressure with a light twisting motion is applied. It should not be inserted to the hub, but rather through the epidermis and the dermis to the fat layer. If a reusable instrument is chosen, it is important to keep it sharpened. The appropriate depth is through the lesion itself, to include the epidermis, and the dermis, with a thickness of 1-2 mm. A biopsy deeper than 3 mm may lead to bleeding and injury of underlying nerves, particularly when vulvar atrophy is present. The tissue from the punch biopsy is then grasped with forceps, pulled upward, and excised with sharp scissors (**FIG. 17.1**).

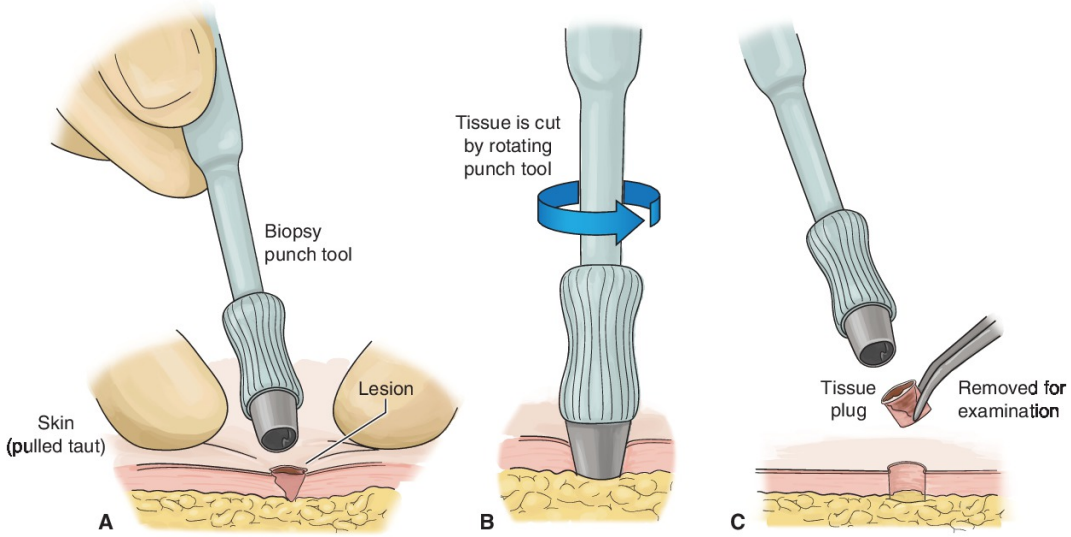


**FIGURE 17.1 A-C.** Keyes Punch.

# Shave Biopsy

A shave biopsy is typically used to remove a raised lesion. A colposcopy biopsy forceps, a scalpel, or scissors may be used to obtain the tissue. In general, the colposcopy forceps are best used for a small lesion that can be grasped in its entirety. When using a colposcopy forceps, it is important that the instrument is sharp so that the tissue is not crushed during removal. Care must be taken to obtain an adequate depth without going too deep into underlying tissues. With this type of biopsy, the area surrounding the specimen should not be pulled taut, but rather may be gently pinched to create a better platform for grasping with the forceps. When using a scalpel or scissors, the tissue may be grasped with forceps and pulled gently upward. One should carefully remove only the lesion and a small sample of surrounding tissue. If too much tissue is tented, a larger sample may be obtained than intended, which can lead to bleeding and may require suturing.

# Excisional Biopsy

If the lesion is polypoid, it can be grasped with the forceps and excised across the bottom of the pedicle with scissors or scalpel. Since hemostasis is readily obtained with such biopsies, sutures are rarely required. If the lesion needs to be excised rather than sampled, a scalpel should be used to remove the tissue in an ovoid shape. If the tissue is thin or ulcerated, a fine suture can be placed to lift the skin to facilitate excision of the lesion. After achieving hemostasis, the ovoid biopsy site can be closed with subcutaneous sutures in order to minimize irritation (**FIG. 17.2**) and achieve good cosmesis. Steri-strips are less likely to stay attached on most of the vulva but may be an effective alternative to use of suture for hemostasis when used on the labia majora. The use of sutures is rarely necessary after a punch or shave biopsy and should be avoided for small biopsies if there is no bleeding since the suture can be irritating in this location. If stitches are required, small-gauge, absorbable sutures placed subcutaneously may be utilized.

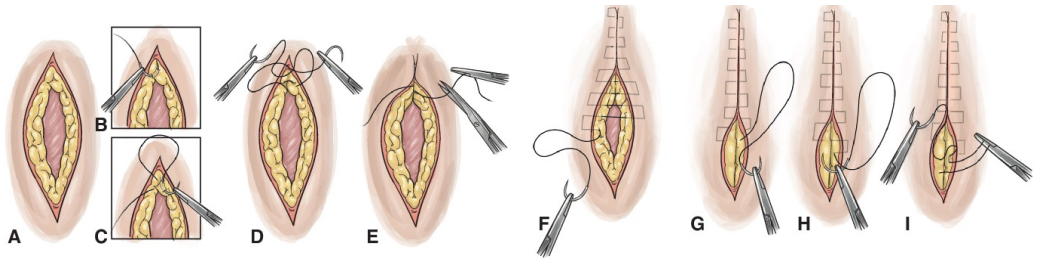


**FIGURE 17.2** Subcutaneous closure. The sequence of figures **(A-I)** illustrates subcutaneous closure with running suture.

When suture closure is unlikely to be required, gentle pressure with sterile gauze should be applied to the site to achieve hemostasis. With deeper biopsies, silver nitrate or Monsel solution can be applied to the inside of the biopsy site to achieve and maintain hemostasis, unless electrocautery is available. Placing a 2″ × 2″ sterile gauze covered with sterile lubricant or antibiotic ointment will prevent the silver nitrate or Monsel solution from irritating the surrounding tissue.

The patient can be instructed to remove it when she next voids. With larger biopsies, antibiotic ointment with an analgesic agent can be applied to the area to prevent irritation with voiding, protect the area from contamination with stool, and prevent infection.

## Biopsy Complications

Complications are rare with vulvar biopsies and include persistent bleeding, infection, and scarring. Avoiding unnecessarily deep biopsies is an important step to prevent these complications. Persistent bleeding can usually be treated with hemostatic agents, cautery, and suturing. Rarely infections resulting from biopsy can occur and may require local wound care measures and, on occasion, the use of systemic antibiotics particularly when significant infections occur in women with poorly controlled diabetes or other immunocompromised disorders. For most women, the pain should be minimal and will resolve quickly, although the area may remain tender to direct touch for a week or so. Patients should be instructed to call with any increasing tenderness or discharge occurring around the biopsy area.

## Postoperative Management

Follow-up visits are usually not required to evaluate the biopsy sites unless there has been extensive suturing or the biopsy was large. If the patient is doing well by a self-report, an examination is not necessary. However, depending on the results, a visit to discuss the findings and a plan for treatment is appropriate.

# SURGERY FOR BARTHOLIN GLAND ABSCESS AND CYST

Bartholin glands are located on the posterior margin of the introitus bilaterally, opening in a groove between the hymen and the labia minora at the 4:00 and 8:00 positions (**FIG. 17.3**). These are located just beneath the fascia and drain into the vestibule. A cyst can occur

when the duct is blocked in one of the glands and usually resolves on its own with conservative measures such as sitz baths, to encourage drainage. Cysts range in size from under 1 to 5 cm. Small cysts are typically not painful while larger cysts can cause discomfort or dyspareunia and may be treated as noted in the section on abscess.

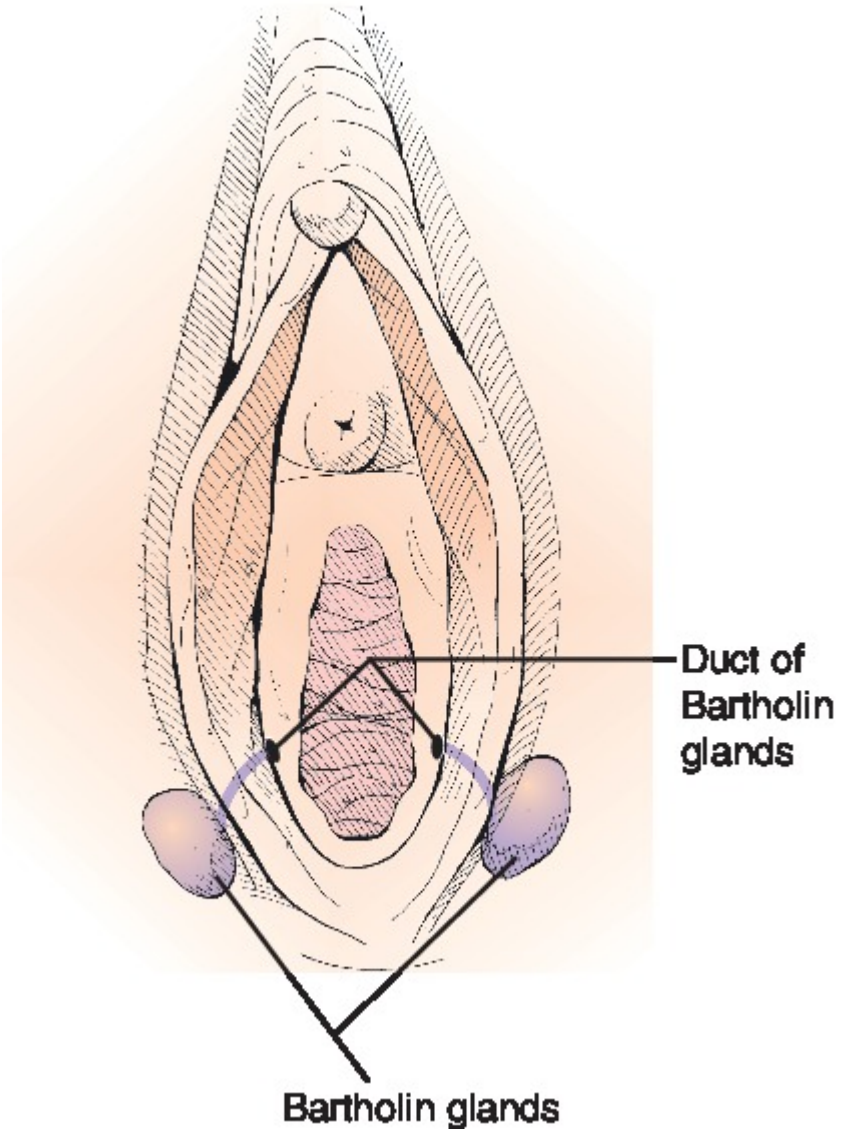


**FIGURE 17.3** Location of the Bartholin glands and ducts.

Abscesses are typically very painful and may be associated with a fever, flulike symptoms, and drainage from the infected gland. When cultures are performed, *Escherichia coli* is the most commonly identified organism, but other Gram-negative aerobes, methicillin-resistant *Staphylococcus aureus* (MRSA), and standard flora can also be found on culture. In adolescents. Gonorrhea and chlamydia are frequently associated with Bartholin abscesses and require concurrent treatment with appropriate antibiotics. While simple incision and drainage can provide relief, there is a higher recurrence rate compared to procedures that result in therapeutic fistulization, which is the process of creating a permanent track for drainage. For most patients, it is much more effective to place a Word catheter, which can be done easily in the outpatient setting, or to perform a marsupialization. The latter can sometime be performed under local anesthetic but may require sedation or even general anesthesia depending on patient tolerance.

Carcinomas of the Bartholin gland account for 5% of vulvar cancers, and <1% of all gynecologic cancers. Postmenopausal women are at higher risk, although the average age of patients developing these cancers is younger than that of patients with other vulvar cancers (age 57 vs 63). African American women may be at higher risk. If there is a solid mass in the Bartholin gland, cancer should be considered in the differential diagnosis.

# Incision and Drainage Using Word Catheter

Bartholin gland abscesses should be treated with incision and drainage due to the painful nature of the abscess and the possibility of resealing the opening. Cysts that are symptomatic due to pressure, dyspareunia, or difficulty walking comfortably should also be drained.

It is important to make sure that there is something to drain. Occasionally, cellulitis with swelling is mistaken for an abscess. If fluctuance is not identified, consideration should be given to performing an ultrasound to identify a fluid collection. In cases of

multiple reoccurrences of an abscess, or recurrent enlargement in a woman over 40 years of age, drainage may be performed as a temporizing measure for symptom relief; however, excision is indicated especially if there are solid components.

Once the patient has been examined and informed consent obtained, it is important to ensure that the required supplies and necessary equipment are in the room. Women may benefit from taking ibuprofen, acetaminophen, or both prior to beginning the procedure. Due to the risk of exposure, operators should wear goggles and a mask, in addition to protecting their lap with a pad. The patient is placed in the dorsal lithotomy position with a protective pad under her buttocks. The vulva should be carefully examined to identify the extent of the abscess and to ensure that it is fluctuant. One should identify an area close to the hymeneal ring (ideally on the vaginal side) on the posteromedial aspect of the vestibule for the incision site. Cleanse the area with antiseptic, and then inject 1-2 mL of local anesthetic subcutaneously at the site of the incision. An additional 5-10 mL can be more broadly injected around the base as a block. The anesthetic will take ~2-3 minutes to take effect (**BOX 17.2**).

## BOX 17.2 SUPPLIES FOR PLACEMENT OF WORD CATHETER

- Protective pad to place under patient to catch drainage
- Gauze sponges (4″ × 4″)
- Culture tube
- Antiseptic such as povidone-iodine or chlorhexidine
- Anesthetic agent such as lidocaine 1% with epinephrine, 3-mL syringe with 25-gauge needle for local anesthetic (can be mixed with sodium bicarbonate in a 1:10 ratio to decrease burning from the lidocaine)
- Scalpel (no. 11 or no. 12 blade)

- Small hemostats (curved and straight)
- Forceps with teeth
- Word catheter, 3-mL syringe, 22-gauge needle

Retract the skin with the nondominant hand and use firm pressure with the scalpel to open a 0.5- to 1-cm incision into the cyst or abscess cavity until fluid or pus is encountered. If a culture is being performed, the swab can be placed through the incision at this point. Hemostats should be used to break up any adhesions and identify all loculations of fluid collection. Gentle external pressure on the abscess or cyst will ensure that all fluid is drained.

The Word catheter (**FIG. 17.4**) should be tested by injecting 3 mL of sterile fluid (not air) into the balloon prior to insertion to ensure there are no leaks. The balloon is then deflated, and the catheter is inserted into the cavity. Grasping the tip with a hemostat is often helpful to guide the catheter into the cavity. The sharp-toothed forceps can be used to grasp the edge of the cyst wall and the skin together to ensure proper placement. Inject up to 3 mL of sterile saline or sterile water into the bulb (do not use air). It should stay in place when pulled gently. The end of the catheter should be tucked into the vagina.

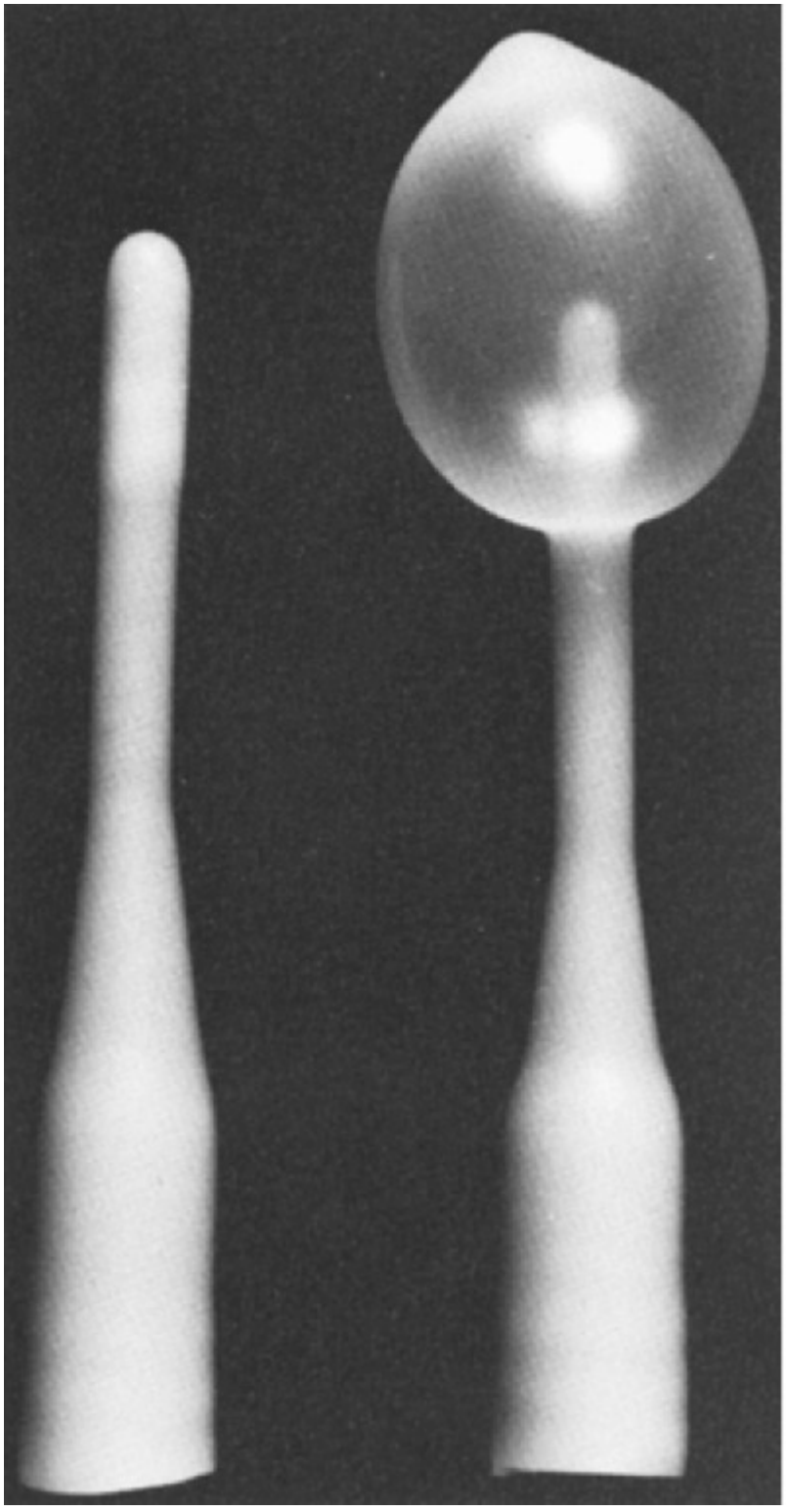

**FIGURE 17.4** Word catheter.

The catheter should ideally be left in place for 4-6 weeks to ensure fistulization; otherwise the likelihood of recurrence is high. Antibiotics should be given if the patient is pregnant, immunosuppressed, MRSA is present, the abscess is recurrent, or there is a concurrent infection with gonorrhea or chlamydia.

The primary complications are premature closure of the duct or failure of a fistula track to develop. These are more likely to occur if the Word catheter is not placed fully into the cavity of the cyst or abscess. Bleeding and hematoma formation are unlikely unless the scalpel blade is inserted too deeply or there is no fluid collection. The recurrence rate is significantly lower with placement of a Word catheter than with drainage alone.

An alternative to the Word catheter is a ring catheter, such as a Jacobi ring catheter. In this case, an incision is made in the same way as a Word catheter. Then a hemostat is used to create a tunnel through the cyst/abscess superiorly where a second incision is made. A thin tube with a suture passed through it is threaded through the tunnel. When the suture is tied a closed ring is created, along with two drainage tracts. One advantage is that the ring cannot be expelled (**FIG. 17.5**).

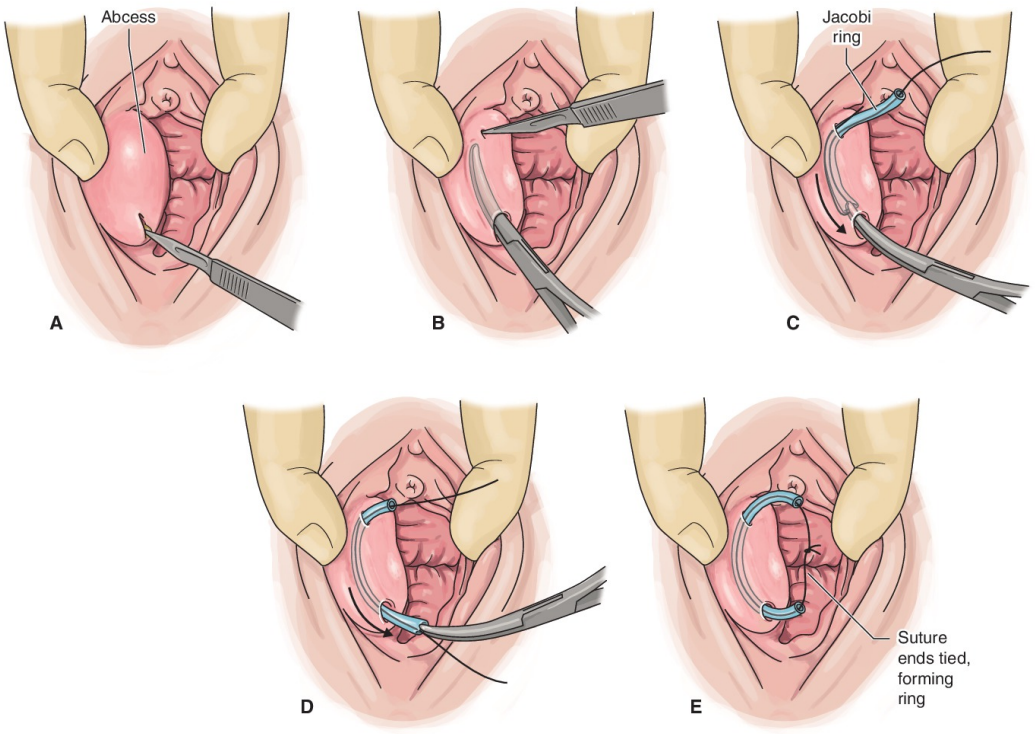


**FIGURE 17.5** Jacobi ring placed for treatment of Bartholin gland duct abscess. **A.** An incision is made into the mucosal surface of the Bartholin duct abscess. Adhesions are lysed, and the abscess is allowed to drain. **B.** A hemostat is tunneled into the abscess cavity and a second incision is made. **C.** The hemostat is used to grasp one end of the Jacobi ring. **D.** The Jacobi ring is pulled through the abscess cavity with care so that the suture is not pulled out of the catheter. **E.** The two ends of the suture are tied, forming the closed ring. (Redrawn from Omole F, Kelsey RC, Phillips K, et al. Bartholin duct

cyst and gland abscess: office management. *Am Fam Physician*. 2019;99(12):760-766.)

## Marsupialization

Marsupialization is an alternative to Word catheter placement to drain symptomatic Bartholin glands. It is also indicated for recurrent cysts or abscesses that have failed prior treatment efforts. Marsupialization of an uninfected cyst can be performed in the office with local anesthesia in a patient with good pain tolerance. Patients may also undergo the procedure in the operating room with local anesthesia and sedation or a regional block. Marsupialization ideally should not be performed for an abscess or when the tissue is inflamed since the fistula may close prematurely. The supplies needed are similar to those listed in **TABLE 17.2**. Closure with absorbable suture that is nonreactive such as Vicryl is preferred.

The steps are identical to those described above for incision of the abscess or cyst, with placement of the incision in the vaginal entrance beyond the hymeneal ring. After the scalpel enters the cavity, the incision is extended for 1.5-3 cm. The cyst wall is identified and grasped with forceps, and interrupted sutures are placed circumferentially, attaching the cyst wall to the fascia and skin to create a permanent opening (**FIG. 17.6**). In women who are postmenopausal, the cyst wall should be biopsied, since the risk of malignancy is higher. Postoperative antibiotics are not necessary unless the patient falls into one of the categories previously discussed. Patients should be seen in 1 week to assess healing. Taking sitz baths after the first 24 hours can help to keep the area clean and aid in symptom relief. In general, the area heals within 2 weeks. Nonsteroidal anti-inflammatory drugs and acetaminophen are generally sufficient for pain management.

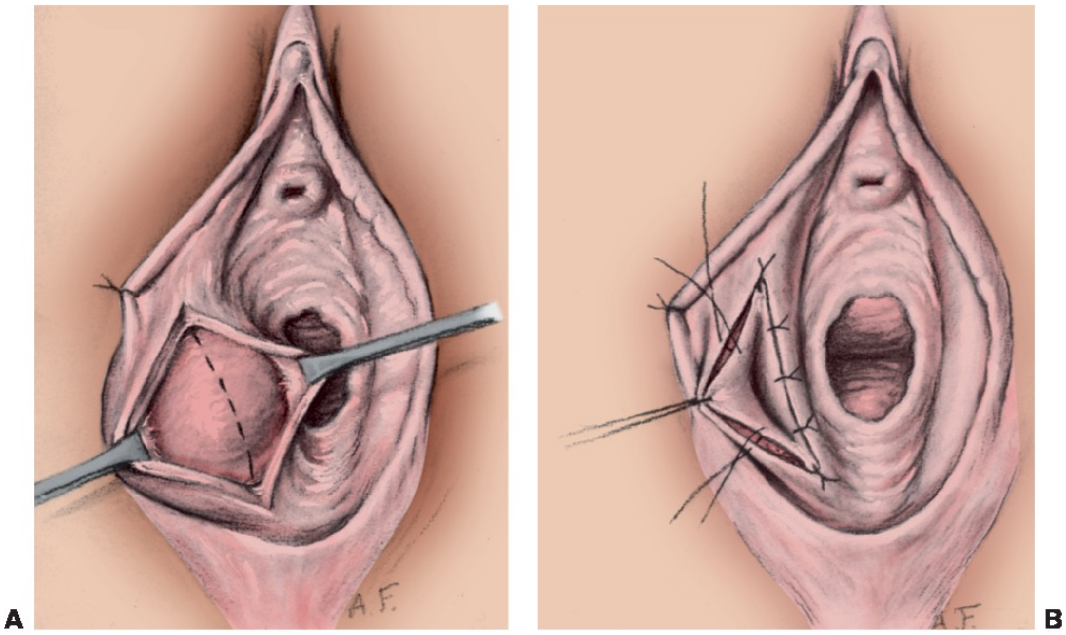


**FIGURE 17.6** Marsupialization of the Bartholin gland. **A.** Incision of skin over the Bartholin gland. **B.** Approximation of cyst wall and skin to create fistula for drainage, also called marsupialization. (Reprinted with permission from Tancer ML, Rosenberg M, Fernandez D. Cysts of the vulvovaginal [Bartholin's] gland: technic and results of treatment by marsupialization. *Obstet Gynecol*. 1956;7(6):608-610. Copyright © 1956 by The American College of Obstetricians and Gynecologists.)

There is a slightly higher risk of bleeding, hematoma formation, superimposed infection, and scarring with marsupialization as compared to Word catheter placement. The recurrence rate is estimated to be as high as 10%-15%.

# Excision

Excision of the Bartholin gland is rarely indicated except for a persistent deep infection or recurrences that have not responded to other measures including marsupialization, or recurrent symptomatic gland enlargement in a woman over 40 years of age. In the latter cases or when there is suspicion for malignancy, a biopsy should be performed prior to excision since premalignant or malignant lesions of the Bartholin gland are usually treated similarly to other vulvar malignancies (**TABLE 17.5**).

## TABLE 17.5
## Indications for Performing Vulvar Biopsy

- When the diagnosis is uncertain
- Irregular or unusual pigmentation
- Signs of inflammatory reaction: induration, ulceration, bleeding
- Rapid growth
- Postmenopausal woman
- Immunocompromised state
- Viral lesion (wart) that is refractory to medical therapy or is flat

When excision is indicated, it should be performed under general or regional anesthesia. Patients who are anticoagulated should discontinue medication prior to surgery due to the risk of bleeding with this procedure. Prophylactic antibiotics should be considered for anyone who is immunocompromised.

The patient should be placed in the dorsal lithotomy position and the vulva prepped and draped in a sterile fashion. A thorough examination under anesthesia, including a rectal examination, will help to define the size and outline of the gland. An incision should be made on the medial aspect of skin overlying the gland and should be carried through the skin, and fascia, but not into the gland itself. An initial incision of 3 cm in length can be extended if necessary. Careful dissection around the intact gland to separate it from the surrounding

tissue should be performed with attention to hemostasis until the gland is removed. The deep space should be closed in layers with absorbable 3-0 suture to minimize the risk of fluid collection, hematoma, and abscess. The skin is closed with an absorbable 4-0 suture in a subcutaneous fashion. Placement of a drain to allow for drainage of purulent material and decrease the risk of a hematoma is optional (**FIG. 17.7**).

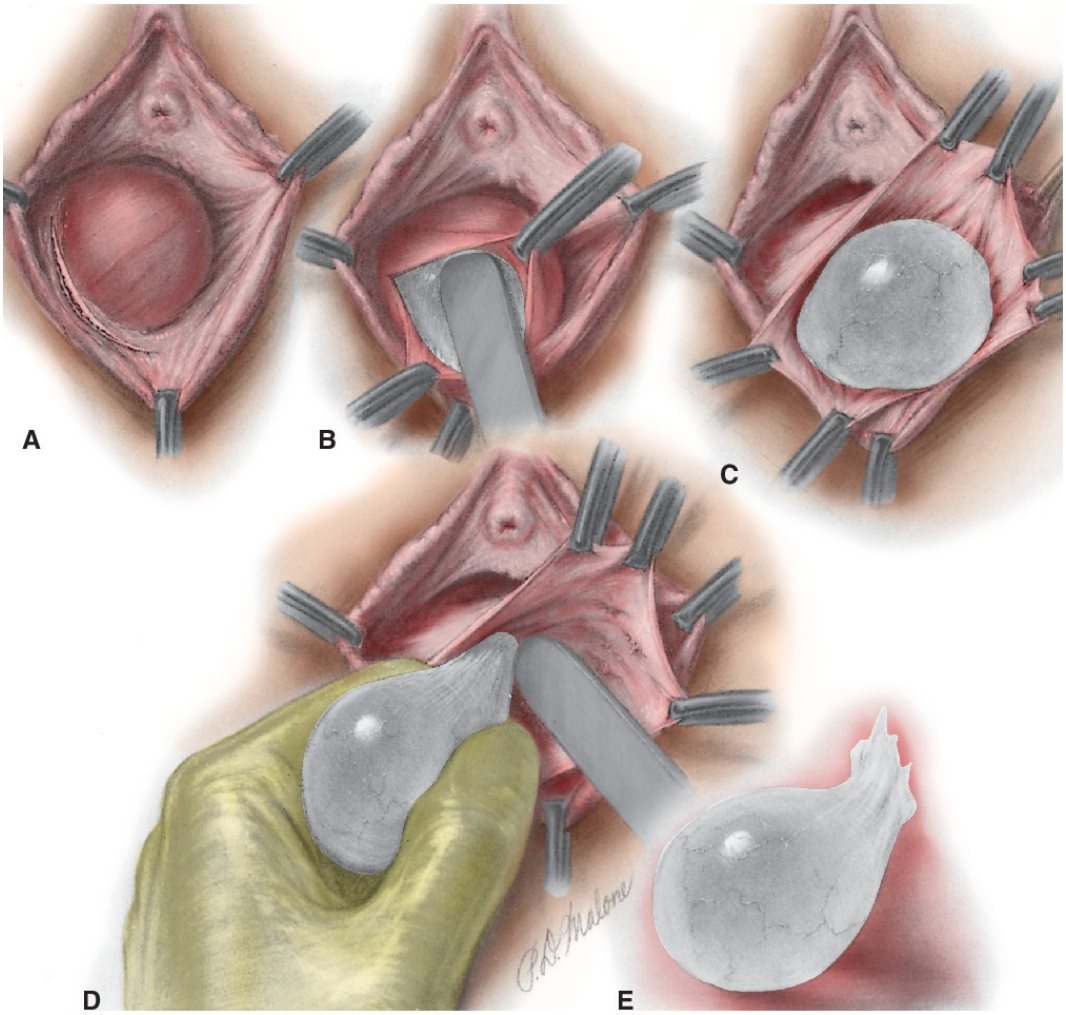


**FIGURE 17.7** Excision of the Bartholin gland. **A.** Enlarged Bartholin gland cyst. **B.** Incision of epithelium overlying gland. **C.** Enucleation

of gland. **D.** Excision of base of gland. **E.** Bartholin gland cyst.

Postoperatively, the perineum should be kept clean by use of a squirt bottle filled with lukewarm water and patted dry (or dried with a hair dryer on low heat). An ice pack covered with a cloth may be applied for the first 24 hours. A follow-up visit in 1-2 weeks is important to assess healing and pain. Further follow-up should be determined at that visit based on clinical indications. Pain can be managed with use of nonsteroidal anti-inflammatories and acetaminophen. Narcotics are rarely indicated. The use of a "donut" to sit on may provide some relief.

The most common complication of Bartholin gland excision is bleeding, either intraoperatively or postoperatively. Careful attention must be paid to obtaining hemostasis. In addition to discussion of the risk of bleeding, risks of infection, scarring, disfigurement, and persistent pain should be included in the informed consent discussion. The Bartholin gland is a major source of lubrication for the vagina, so excision may lead to vaginal dryness and dyspareunia. Incomplete resection can lead to recurrent cyst formation, and repeat procedures are made difficult by the scarring and distortion of anatomy that occurs after the initial surgery (**TABLE 17.6**).

## TABLE 17.6
## Risks of Bartholin Gland Excision

- Incomplete removal of the gland
- Hemorrhage
- Hematoma
- Loss of vaginal lubrication postoperatively
- Scarring
- Chronic pain and/or dyspareunia

# ABLATIVE PROCEDURES

The most common vulvar lesions treated with ablation are condyloma acuminata, skin tags, molluscum contagiosum, actinic keratosis, and seborrheic keratosis. Vulvar intraepithelial neoplasia may also be treated with laser ablation once colposcopy and biopsy have ruled out the presence of invasive disease.

There are a number of different types of vulvar ablative procedures that have been described: carbon dioxide laser, cryotherapy, and silver nitrate application are the most well studied. All of these procedures can be performed safely in the office or in the operating room. Although silver nitrate is technically considered an ablative agent, its use on the vulva is primarily to control small areas of bleeding. Both laser and cryotherapy require special equipment. The carbon dioxide laser can be costly to acquire and maintain, particularly with the need for stringent safety protocols and training of staff and providers. Thus, it is not practical to purchase and maintain if use is infrequent. The equipment for cryotherapy consists of a container for liquid nitrogen and tubing as well as a hand-held control and regulator, which allows various-sized tips to be attached.

There are few contraindications to ablative therapy. The most important is that it should not be used unless there is diagnostic certainty about the lesion or disease process since ablation destroys the lesion, and with that the ability to obtain tissue for diagnostic evaluation. In order to perform these procedures in the outpatient setting, the patient must be able to tolerate local anesthesia and remain still for the duration of the procedure. There is a risk of damage to normal tissue if the patient moves suddenly. For this reason, extensive lesions should be treated using general or regional anesthesia in an operating room. Active infection is an absolute contraindication, and immunosuppression is a relative contraindication. Immunosuppressed patients will take longer to heal and are at higher risk for developing postoperative infection, which is otherwise rare. However, the immunosuppressed state may be the cause of the proliferation of viral lesions such as condyloma or molluscum.

# Cryotherapy

Cryotherapy involves the use of liquid nitrogen to create extremely cold temperatures (−50 °C to −60 °C). There are both open and closed spray tips, which are used with a freeze/thaw cycle. The length of the cycle and the number of cycles will vary depending on the extent of the lesion and the depth of treatment. Typically, benign lesions are destroyed at a temperature of −20 °C to −30 °C. This procedure does not require a sterile field, since the cold itself will kill organisms. The steps for ablation using cryotherapy are described in **BOX 17.3** and **TABLE 17.7**.

## BOX 17.3 STEPS IN THE PROCEDURE

### Cryotherapy

- Cleanse the lesion with water and wipe away any discharge or mucus.
- Retract the labia if necessary, keeping fingers and instruments outside of the field of spray if using that type of tip.
- Apply local anesthetic under the lesion to create a wheal. This may not be necessary on less sensitive tissue such as the mons.
- Position the tip of the spray 1-1.5 cm from the lesion or the probe directly on the lesion if using a closed system.
- Spray or continue holding the closed probes against the lesion until a 2-mm rim of frost develops around the lesion, and then continue for an additional 5-30 seconds based on the characteristics of the lesion (**TABLE 17.7**). If a probe is being used, it may take a minute or two for some thawing to occur to release it from the skin although some cryotherapy systems have a defrost component that speeds up the process.

## TABLE 17.7
## Freeze Times for Cryosurgery

| TYPE OF LESION | FREEZE TIME |
|---|---|
| Actinic keratosis | 5-20 seconds |
| Seborrheic keratosis | 5-10 seconds |
| Condyloma or molluscum | 10 seconds |
| Skin tags | 5 seconds |

# Carbon Dioxide Laser

Carbon dioxide laser ablation for treatment of vulvar lesions can be performed using gross visualization or through a colposcope, which allows for magnification of the target area, and more precision. It can also be performed freehand for larger lesions or areas that are clearly visible to the naked eye. Safety is an important consideration: the patient and operators should wear masks and goggles throughout the procedure. There is a theoretical risk of vaporized viral particles being released into the air and inhaled, causing warts in the mouth and throat, so masks that can block small particles should be worn by the surgeon and all assistants. A smoke evacuator should be used to aspirate viral particles. The patient may have moist gauze/cloth placed over her eyes or goggles unless there is a barrier with a surgical drape. Eyeglasses are not sufficient for protection. Complications are more likely if the ablation reaches the dermis, so it is important to be cognizant of the depth of treatment and stay within 3 mm. With lesions that are large and raised, this risk may be greater because it may be difficult to judge the depth (**BOX 17.4**).

## BOX 17.4 STEPS IN THE PROCEDURE

## Carbon Dioxide Laser Ablation

- Define the area to be treated with colposcopy and application of acetic acid.
- Place wet towels around the surgical area to absorb possible errant laser beam.
- Operator, assistant, and patient wear protective masks and eyewear.
- Set up and turn on the smoke evacuator.
- Test the laser on a moistened tongue depressor.
- Set the wattage (10 W for most lesions, 4-6 W for flat warts).
- Set the spot size to a defused setting. With freehand laser, this is controlled by distance from the treatment area.
- The area to be ablated may be outlined initially with the laser and then filled in to complete the procedure.
- Ablate 2-3 mm in depth, with a margin of up to 1 cm.

Pain in the postoperative period can be controlled with acetaminophen and/or nonsteroidal anti-inflammatory agents. Regular application of an antibacterial ointment will help prevent infection and adherence of the labial folds when treatment has been extensive. Some preparations contain a local anesthetic and can ease discomfort. If there is an increase in irritation with the use of an ointment, then petroleum jelly may be preferable, particularly if an allergic reaction is suspected. Use of sitz baths 2-3 times per day (starting 24 hours after treatment) in the 1st week can assist with healing, keep the vulva clean, and provide some symptom relief. Follow-up should be scheduled in 1-4 weeks depending on the immune status of the patient, to confirm that there is no adherence of the labia (depending on location and extent of the ablation) and to determine if further treatment is indicated.

The primary risks associated with ablative therapy include minor complications such as erythema, burning, formation of blisters,

temporary hyperpigmentation at the site (which typically resolves in 6 weeks), and pain or discomfort. Bleeding is a rare complication. More serious complications include infection, scarring, delayed healing, and prolonged hypopigmentation, which occurs more commonly in people with darker skin. Postoperative vulvodynia has been described after laser ablation and should be addressed during the informed consent process.

# SURGERY FOR VESTIBULE DISORDERS

The vestibule is the area on the vulva between the hymen and Hart line (a visible line reflecting more keratinized skin on the labia minora). It extends posteriorly to the fourchette and anteriorly to the frenulum of the clitoris. The urethra and vestibular glands are contained within this area. A wide range of procedures have been described over time that involve excising all or part of the vestibule, generally for the relief of vulvodynia, a chronic vulvar pain process that is often idiopathic.

The primary indication for vestibulectomy is vulvodynia, which persists after more conservative therapies such as pelvic floor rehabilitation and medical treatment. Vulvodynia is a diagnosis of exclusion, because treatable causes must be ruled out. Vestibulectomy should be reserved for women who have had a workup for pain interfering with their ability to have sexual intercourse and who have failed all other treatments. Cotton swab testing should be used to map the areas of pain and intensity to determine that a vestibulectomy will include all of the painful areas. Surgery is generally considered to be a last resort after medical treatments for vulvodynia have failed and is more commonly offered for provoked, idiopathic vulvodynia when pressure on the vulvar vestibule results in significant discomfort. The success rate of surgical treatment is only about 50%-60%. The procedures used are variously referred to as vestibulectomy, including modified or posterior vestibulectomy, and vestibuloplasty. A simplified vestibulectomy described by Goetsch has been shown to be

effective for vulvodynia, particularly when combined with pelvic floor therapy.

Vestibulectomy is an elective procedure intended to relieve pain and allow the patient to have intercourse comfortably. Therefore, the patient's preoperative condition should be optimal. There should be no signs of inflammation or infection, and the patient should be medically stable and not anticoagulated. Women who are immunocompromised are at increased risk of complications, and caution is advised before embarking on a surgical approach for these patients.

# Vestibulectomy

To perform vestibulectomy, the patient is placed in the dorsolithotomy position. The areas of pain are mapped, using a cotton swab, while the patient is still awake preoperatively. A marker should be used, first to identify the points of tenderness and then to outline the area for excision. The vulva is then prepped and draped in a sterile fashion. Vestibulectomy is performed as an outpatient procedure and on occasion can be performed in the office when the area is small, but for larger areas, general or regional anesthesia is recommended. Even with general or regional anesthesia, local infiltration with lidocaine and epinephrine is recommended as this will provide postoperative pain relief and assist with hemostasis during the procedure. A number 15 scalpel blade is used to excise the outlined area to a depth of 2-5 mm, taking great care around the urethra when anterior dissection is necessary. The skin under the hymen (if not excised) and vagina should be undermined to create a flap for closure. Closure is performed with a deep layer of interrupted stitches using 3-0 Vicryl followed by running or interrupted sutures to close the mucosa with 4-0 Vicryl (**BOX 17.5**).

## BOX 17.5 STEPS IN THE PROCEDURE

### Vestibulectomy

- Map the areas of pain/tenderness with cotton swab.

- Infiltrate with local anesthesia (lidocaine with epinephrine) (**TABLE 17.3**).
- Perform sharp dissection of the area with no. 15 scalpel blade.
- Remove tissue (2-5 mm depth).
- Close the deep layer with interrupted sutures using 3-0 absorbable suture.
- Close the mucosa with running or interrupted sutures using 4-0 absorbable suture.

Postoperatively, ice packs should be applied to the perineum for 24-48 hours postsurgery, and use of sitz baths can be started after 24 hours to relieve discomfort. The patient should be instructed to avoid intercourse or insertion of anything, such as tampons, into the vagina until cleared by her surgeon. Rigorous activity that would cause rubbing or undue pressure in the vulvar region should be avoided in the first 2 weeks after the procedure. Intercourse can be resumed 6-8 weeks postoperative when the incision has healed. Antibiotics are not indicated for this procedure. A postoperative visit can be scheduled at 4-6 weeks postoperatively to assess healing.

Complications of vestibulectomy include bleeding, hematoma formation, infection, scar formation, wound separation, and need for additional surgery to repair incision breakdown. In addition, Bartholin cyst formation can occur in up to 9% of patients, typically within the first few months after surgery. The patient may not be pleased with the cosmetic effect and should be counseled about this preoperatively. Decreased lubrication may require the use of a vaginal lubricant for intercourse in up to 25% of treated women. Recurrence after an initially successful surgery is relatively rare, with a reported incidence ranging from 0% to 13%.

# VULVAR NECROTIZING SOFT TISSUE INFECTIONS

Vulvar necrotizing soft tissue infections (NSTIs) are associated with significant morbidity and mortality but occur infrequently. They are characterized by rapid progression and extensive involvement of the affected tissue which can include skin, fat, fascia and muscle. Initially, the disorder may mimic cellulitis with minimal findings except for pain out of proportion to the skin appearance, a finding not characteristic of cellulitis. As the disorder progresses, the overlying skin appears darkly discolored, edematous, or necrotic. These findings are secondary to thrombosis of the vasculature underlying the skin with resultant ischemia. Bullae and crepitus may be noted and the subcutaneous tissue below the skin may develop wooden-hard induration. In addition, fever and hemodynamic instability can be present. When the disorder presents as necrotizing fasciitis there may be skin anesthesia preceding the appearance of necrosis, leading to a possible delay in diagnosis. Risk factors for vulvar NSTIs include obesity, diabetes mellitus, hypertension, advanced age, atherosclerosis, immunosuppression, recent gynecologic or obstetric surgery, and trauma. The reported mortality rates range between 6% and 76%.

Laboratory findings associated with vulvar NSTI are nonspecific but may include leukocytosis, and abnormal electrolytes, creatinine, and coagulation studies. Elevations of creatine kinase and aspartate aminotransferase suggest deep infection as opposed to cellulitis. Imaging studies demonstrating soft tissue gas, fluid collections, and inflammatory changes may aid in establishing a diagnosis of vulvar NSTI when clinical findings are only suggestive of the diagnosis (**BOX 17.6**).

## BOX 17.6 CLASSIC FINDINGS WITH NECROTIZING INFECTIONS

- Erythema, edema, and warmth
- Systemic symptoms (fever, hypotension)
- Pain out of proportion to appearance
- Bullae, necrosis, discoloration of skin

- Crepitus
- Firm, indurated tissue
- Rapid progression of infection

Vulvar NSTI is primarily a clinical diagnosis. Successful outcomes depend on early recognition coupled with prompt and aggressive surgical débridement. This should be conducted in an operating room with adequate anesthesia. When findings are strongly suggestive of a vulvar NSTI, surgery should not be deferred while awaiting laboratory or radiographic results since delay increases the risk of morbidity and mortality. The presence of gas in soft tissues is highly specific for NSTI and should prompt débridement surgery (**FIG. 17.8**).

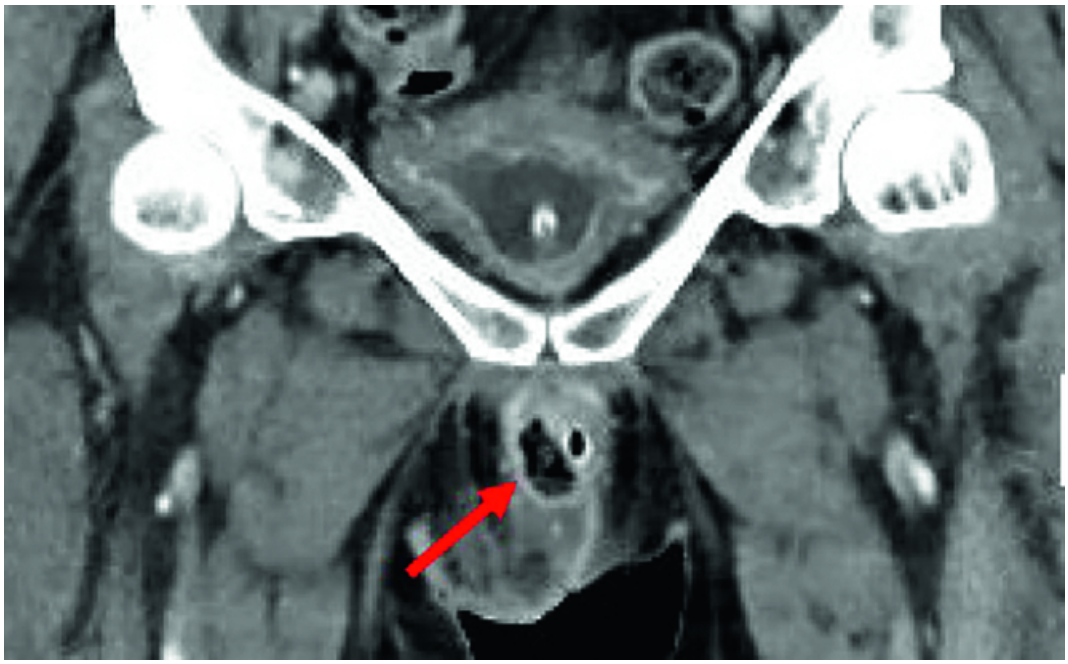

**FIGURE 17.8** CT imaging showing soft tissue stranding and gas (*arrow*) in patient with vulvar NSTI.

# Debridement

During the initial procedure, blood cultures should be obtained, if not already drawn, and multiple biopsies and tissue cultures should be taken from several sites for both histologic evaluation as well as culture for pathogens. Empiric antimicrobial therapy should be instituted until the culture results allow for more specific coverage (**BOX 17.7**). The infecting organisms are usually either polymicrobial with aerobic and anaerobic bacteria or monomicrobial due to group A Streptococci (GAS). Incisions need to be big enough to allow adequate débridement of the necrotic subcutaneous tissue, fascia, and muscle. Due to necrosis, the tissue planes can usually be separated bluntly. Purulent fluid is uncommon but there may be significant amounts of a thin exudate. Debridement should extend until bleeding is encountered indicating the presence of healthy tissue. Copious irrigation with an antiseptic solution that has minimal cytotoxicity should be carried out during and at the completion of debridement. At the conclusion of the procedure, antiseptic dressings are usually applied. Wound sites should be assessed several times a day in the acute period to determine if additional debridement is required to gain source control. It is common that additional procedures will be required daily for several days after the initial surgery. If there is evidence of more rapid progression, debridement may need to occur at more frequent intervals. Using skin marking to document the edges of initial dissection can assist in determining the disease progression (**FIG. 17.9**).

**FIGURE 17.9** Vulvar necrotizing soft tissue infection after initial debridement. Skin marking outlines extent of erythema and is

used to monitor for further progression of the infection.

## BOX 17.7 EMPIRIC ANTIBIOTIC TREATMENT OF VULVAR NECROTIZING SOFT TISSUE INFECTIONS*

Piperacillin-tazobactam 3.375 g IV every 6-8 hours
(or another carbapenem such as imipenem, meropenem, or ertapenem)

PLUS

Vancomycin 15 mg/kg IV every 12 hour

PLUS

Clindamycin

Adapted from Stevens DL, Bisno AL, Chambers HF, et al. Practice Guidelines for the Diagnosis and Management of Skin and Soft Tissue Infections: 2014 Update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2015;15(2):e10-e52.

*Initiate until culture results suggest alternative therapy.

Application of negative pressure wound therapy for wound closure is frequently utilized at many centers. Some studies suggest that use of intravenous immune therapy and hyperbaric oxygen therapy may also be helpful in the treatment of this disorder. Surgical reconstruction such as that offered by a plastic surgery service may also be required for wound closure especially for larger wounds. The complexity involved in the care of such critically ill patients often requires transfer to a tertiary care facility that has individuals skilled in management of complex wounds, supportive critical care, perineal reconstruction, and rehabilitation. However, since successful outcomes are highly dependent upon early surgical treatment, the

initial surgery should be undertaken at the initial facility providing care prior to transfer if possible.

# LABIAPLASTY

Labiaplasty is reduction of the size of the labia minora. There has been a great debate whether this surgery is appropriate when requested for purely cosmetic reasons. There are few medical indications that warrant the procedure. It is important to inform women about the risks and to be able to recognize when a psychological evaluation would be helpful prior to the procedure. Most techniques are fairly straightforward, but some are quite complex and are better performed by a surgeon experienced with this procedure. These include custom flap labiaplasty, W-plasty, and deepithelialization. The procedures described here are the edge resection and the wedge resection, which should be well within the skill set of most general gynecologists.

Medical indications for labiaplasty include hypertrophy of the labia minor contributing to development of dyspareunia, chronic irritation, difficulty exercising, or problems with hygiene and infection. In addition, some women may have asymmetry due to injury during childbirth or through other trauma, which can be repaired with surgery. Surgical alteration of the labia on minors, unless necessary for health, is restricted by federal criminal laws. Further, a number of states also have restrictions on the use labiaplasty for all age groups. Physicians contemplating performing labiaplasty should be aware of what laws apply in their own jurisdiction.

Relative contraindications to performing this procedure include immunosuppression, bleeding disorders, and anticoagulated state. It is typically performed in the operating room under general or regional anesthesia. This is an elective procedure and should be performed in healthy women with few comorbidities.

## Edge Resection

For an edge resection, the patient is placed in the dorsolithotomy position, and the vulva is prepped and draped in a sterile fashion.

This technique is performed after marking the line of excision bilaterally to ensure equal proportions of retained labia minora. Planning carefully and marking correctly is the most important part of the procedure. Local anesthesia with lidocaine 1% with epinephrine (and sodium bicarbonate in a 1:10 ratio) can be injected subcutaneously along the excision line. Approximately 5-7 mL should be injected in each labium to provide anesthesia without distorting the labia with a wheal. The excision can be performed with Metzenbaum scissors or scalpel, taking care to keep the incision smooth and avoiding jagged edges (**FIG. 17.10**). Interrupted subcutaneous stitches with 4-0 Vicryl will take the tension off the edges, which then can then be closed with a running subcutaneous suture using the same suture material. Unless mapping is done carefully, there is a significant risk of removing too much tissue because it is easy for the eye to be tricked, creating “dog ears” (**FIG. 17.11**). If noted during the repair, these should be excised immediately. This surgical technique works well when repairing an irregular edge due to injury, although the uninjured side may also need excision to create symmetry. There is risk of developing postoperative paresthesias with this technique.

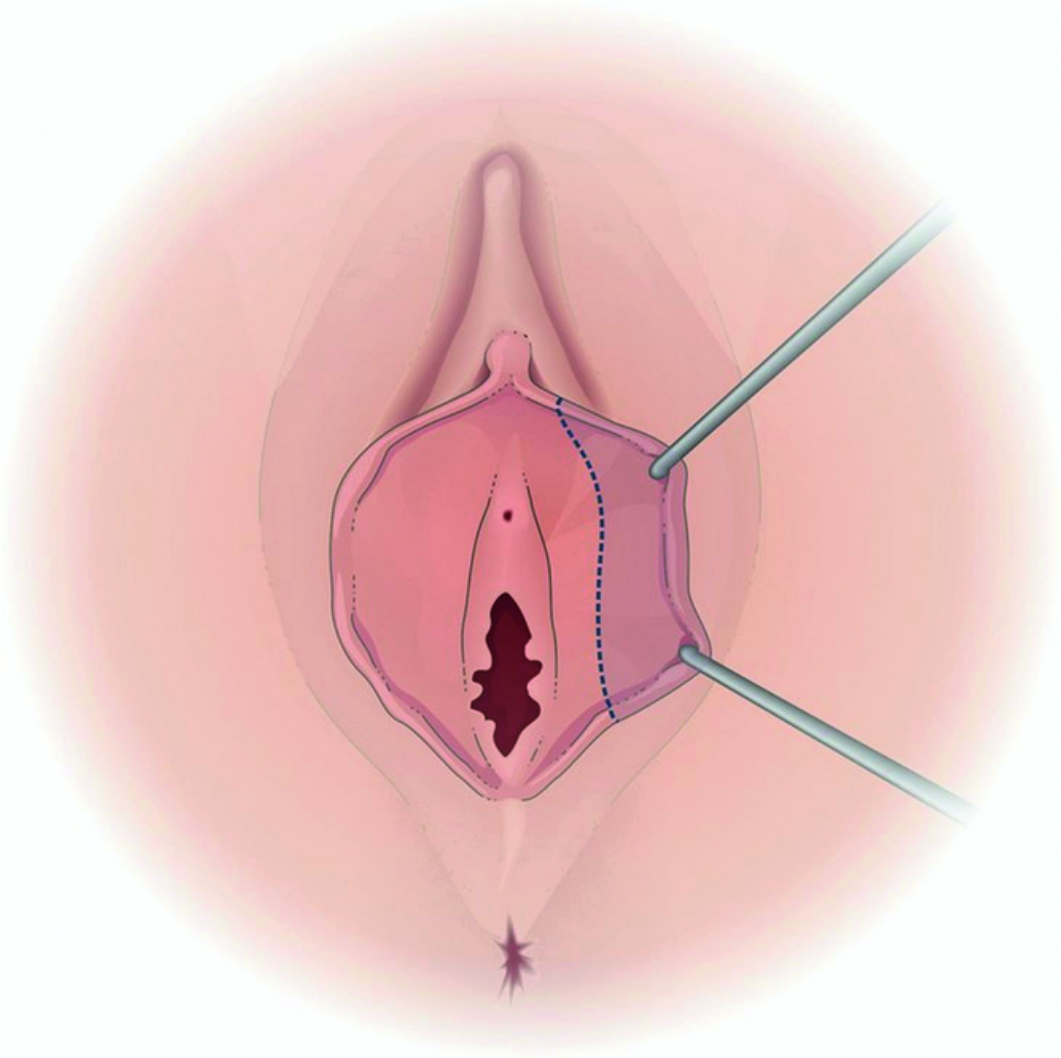

**FIGURE 17.10** Edge resection of the labia. (From Oranges CM, Sisti A, Sisti G. Labia minora reduction techniques: a comprehensive literature review. *Aesthetic Surg J*. 2015;35(4):419-431. Reproduced by permission of The American Society for Aesthetic Plastic Surgery, Inc.)

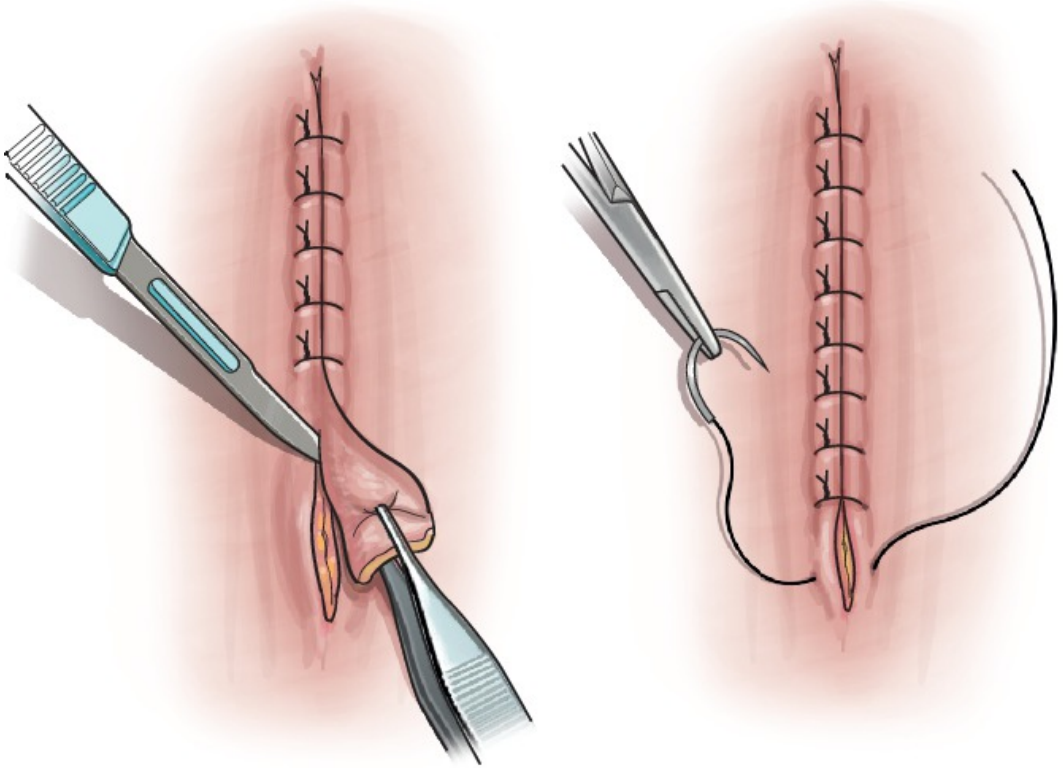

**FIGURE 17.11** Getting rid of "dog ears." (Modified with permission from Blackbourne LH. *Advanced Surgical Recall*. 2nd ed. Lippincott Williams & Wilkins; 2003. Figure 14.1.)

## Wedge Resection

The wedge resection involves excising a wedge-shaped area of labia. Once again, the wedge is outlined with a marker and then injected with local anesthesia. Typically, the wedge is removed from the center of the labia, but modifications have been described based on the shape of the labia and the location of excess tissue. After excision of the wedge, the two edges are closed with two layers. First, a layer of subcutaneous interrupted sutures of 4-0 Vicryl to decrease tension followed by a running subcutaneous stitch with 4-0 Vicryl or 5-0 Monocryl. This technique is best used for hypertrophied

labia when a protruding edge extends 2 cm or more beyond the fourchette. This technique allows for reapproximation of the exposed edges with the creation of a more natural border to the labia. There are a number of modifications to performing this procedure depending on the size and shape of the labia that involve they same basic steps (**FIG. 17.12**; **BOX 17.8**).

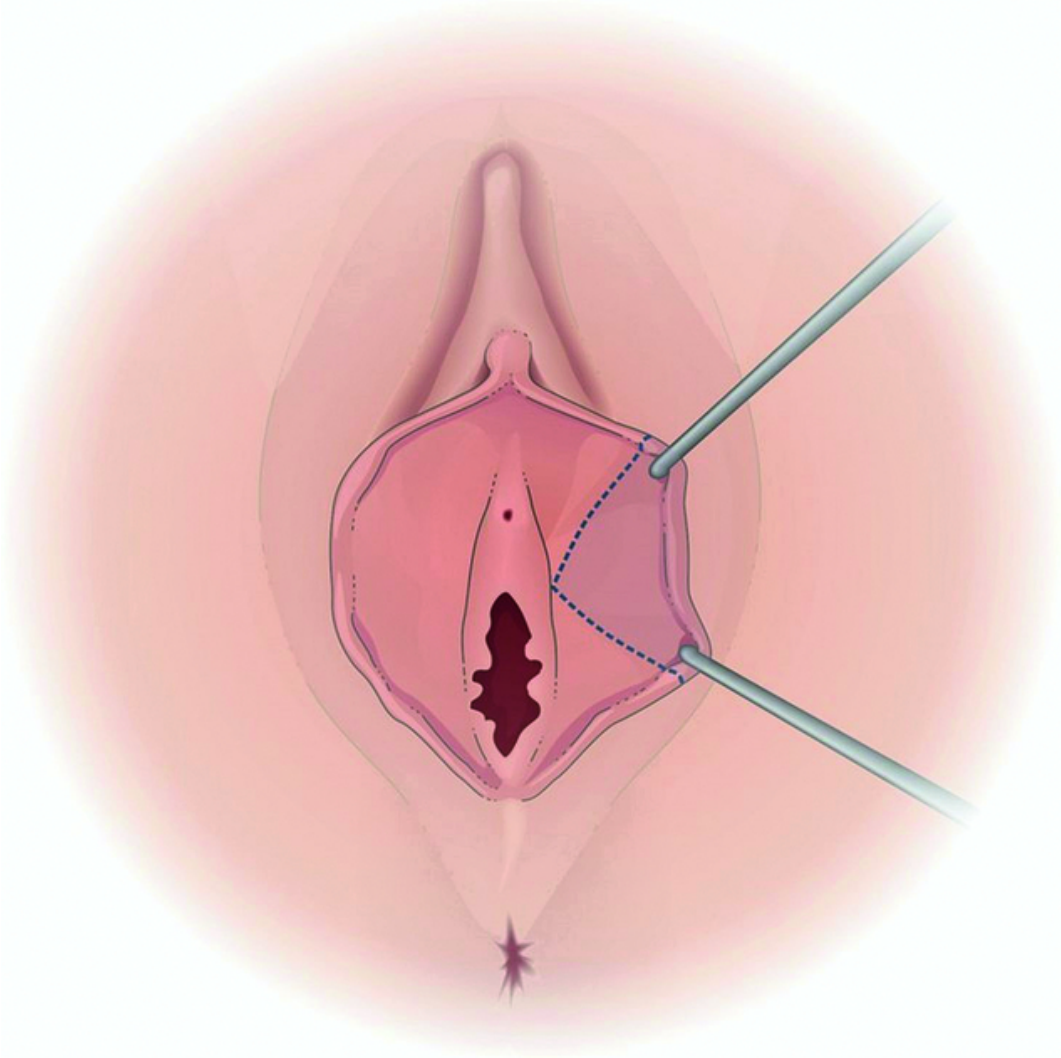

**FIGURE 17.12** Wedge resection of the labia. (From Oranges CM, Sisti A, Sisti G. Labia minora reduction techniques: a comprehensive literature review. *Aesthetic*

*Surg J*. 2015;35(4):419-431. Reproduced by permission of The American Society for Aesthetic Plastic Surgery, Inc.)

## BOX 17.8 STEPS IN THE PROCEDURE

**Labiaplasty**

- Examine the labia and mark the lines of excision.
- Take care to ensure symmetry.
- Inject 1% lidocaine with epinephrine proximal to the marked line.
- Excise the tissue as outlined.
- Use needle-tipped cautery to achieve hemostasis.

**Edge Resection Repair**

- Suture the edge with running subcutaneous sutures using 4-0 absorbable suture.

**Wedge Resection Repair**

- Reapproximate the cut edges of the labia.
- Place interrupted deep sutures for hemostasis and to decrease tension with 4-0 absorbable sutures.
- Close the raw edges with running subcutaneous suture with 4-0 or 5-0 absorbable suture.

# Postoperative Management

Nonsteroidal anti-inflammatory drugs or acetaminophen can be used for pain relief. Antibiotic ointment containing an anesthetic agent can also be used. Ice packs used over the first 24-48 hours can help to reduce the swelling and discomfort, although some swelling of the surgical site may last for up to 4 weeks. Use of sitz baths may also

provide relief after the first 24 hours. The patient should be instructed to call if there is increased pain, erythema, purulent material at the site, or fever. Follow-up in the office in 1-2 weeks is planned to assess healing and for patient reassurance regarding swelling. Intercourse should be delayed until the incisions are fully healed, usually 6-8 weeks after surgery.

Significant edema of the labia is common and should not be seen as a complication. Bleeding, dehiscence, and infection are possible but not frequent complications. Hematomas may occur and should be drained immediately to relieve pain.

# PERINEOPLASTY

Anatomically, the perineum is the entire pelvic outlet below the supporting muscles and fascia. The perineal body is that portion of the perineum that lies between the vagina and anus. Although there are a variety of surgical perineoplasties that can treat major perineal obstetrical lacerations, incontinence, and prolapse, this section will focus on the revision perineoplasty used for relief of persistent pain or dyspareunia related to the vagina introitus.

The major indication for a revision perineoplasty is persistent pain or dyspareunia following a vaginal delivery. This surgery is reserved to treat those individuals who have significant dyspareunia despite nonsurgical treatment such as pelvic floor muscular therapy. It also is indicated if there is significant scarring or skin breakdown at the introitus related to prior obstetrical injury, other trauma, or treatment of other vulvar lesions.

A revised perineoplasty should not be performed early in the postpartum period before normal healing has occurred, in the presence of inadequately repaired third- or fourth-degree perineal lacerations, or if there is persistent and significant rectal incontinence. Further, the surgery does not adequately address other problems such as a cystocele or rectocele. As noted in previous sections, the patient should also not have any medical conditions that would contraindicate surgery or the use of general or regional anesthesia.

# Revision Perineoplasty

The procedure is performed as outpatient surgery in an operating room. The patient is placed in the dorsolithotomy position, prepped, and draped. A triangular incision is made running from each side of the introitus in the perineal skin toward the anus joining together at a point in the midline. The vagina is then undermined to allow exteriorization without undue tension. After completing the triangular incision across the undermined vagina at the introital level, and removing the triangular piece of skin and vagina, the vaginal edges are then approximated to the perineal skin with interrupted sutures such as 3-0 for 4-0 Vicryl (**FIG. 17.13**). Occasionally, the underlying subcutaneous tissue is approximated to reduce tension; however, one should avoid “tenting” the tissue in the midline since it could also lead to subsequent dyspareunia. It is also important that the removed skin and vaginal tissue includes any scar or area of ulceration.

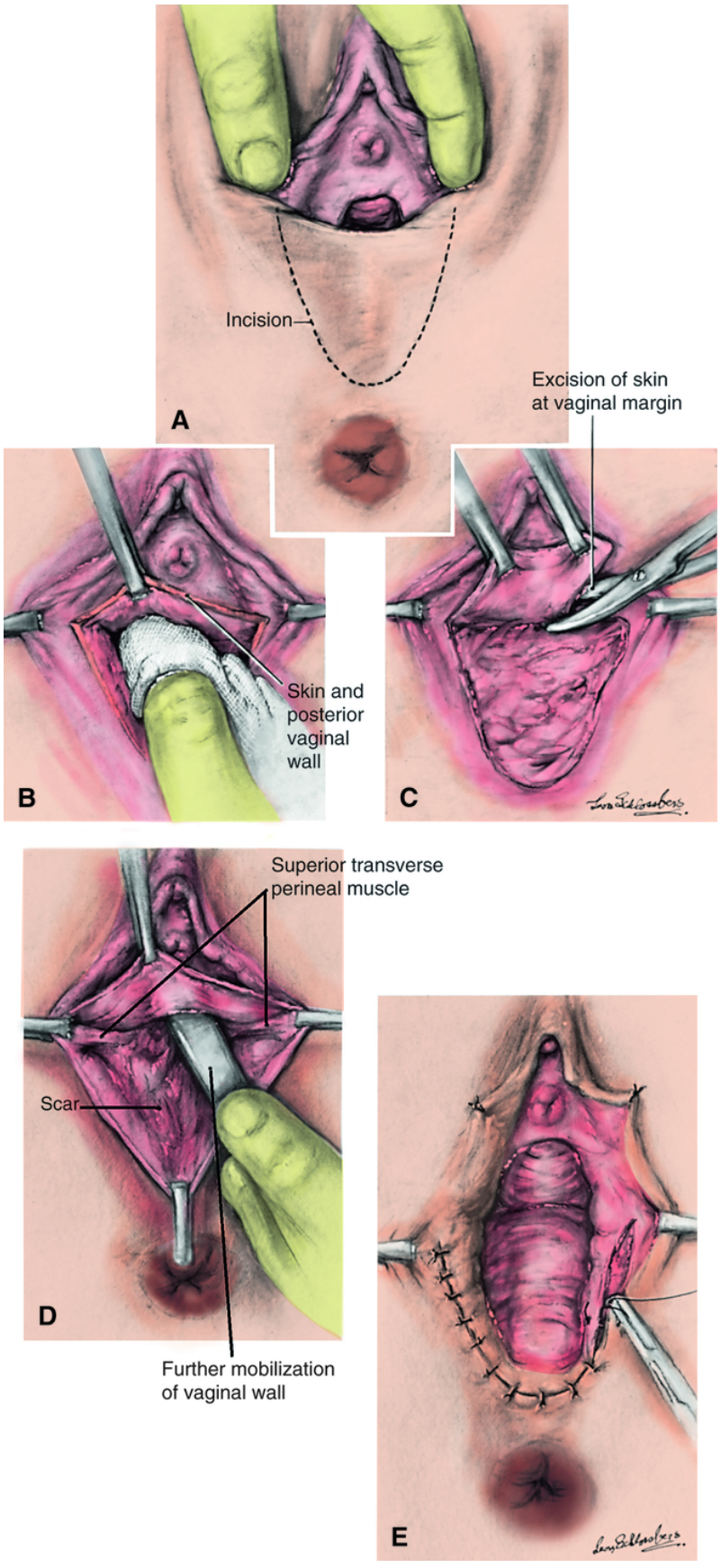
Incision
A
Excision of skin
at vaginal margin
Skin and
posterior
vaginal
wall
B
C
Superior transverse
perineal muscle
Scar
D
Further mobilization
of vaginal wall
E

**FIGURE 17.13 A-E.** Perineoplasty.

Pain is usually adequately managed with nonsteroidal anti-inflammatory agents or acetaminophen as well as sitz baths. Healing occurs in 6-8 weeks. Until then, patients should avoid intercourse or tampon use. A follow-up visit at 4-6 weeks is recommended.

Bleeding, dehiscence, and infection are possible but occur infrequently with this procedure. Avoiding intercourse or tampon use reduces the frequency of these complications. Persistent dyspareunia due to further scarring occurs rarely.

## KEY POINTS

- Most vulvar minor procedures can be performed safely in the office.
- One should have a low threshold to biopsy a lesion of uncertain etiology or with recent changes.
- Bartholin cysts and abscesses should have a fistula track created at the time of drainage to minimize the risk of recurrence, either through placement of a Word catheter or through marsupialization.
- Ablation techniques can be performed safely in the office and require special equipment.
- Surgical debridement is the mainstay for treatment of necrotizing infections.
- Vestibulectomy is performed as a last resort for dyspareunia unrelieved by other approaches.
- Labiaplasty and perineoplasty are uncommonly indicated for dyspareunia or other symptoms.

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# CHAPTER 18

# TUBAL STERILIZATION

Amy G. Bryant and Jessica E. Morse

**Preoperative Evaluation**

**Tubal Sterilization Procedures Performed by Minilaparotomy**

Postpartum Tubal Sterilizations

Interval Tubal Sterilization

Complications Associated With Sterilization Performed by Minilaparotomy

**Tubal Sterilization Procedures Performed Laparoscopically**

**Bipolar Coagulation**

Unipolar Coagulation

Nonthermal Methods of Tubal Occlusion

Complications Associated with Laparoscopic Sterilization

**Hysteroscopic Tubal Occlusion**

**Bilateral Salpingectomy**

Salpingectomy at Cesarean Section

Postpartum Bilateral Salpingectomy

Interval Bilateral Salpingectomy

Surgical Complications From Bilateral Salpingectomy

**Sterilization Efficacy**

**Sterilization Safety**

**Long-term and Delayed Complications From Tubal Sterilization**

**Menstrual Changes After Sterilization**

**Regret**

Tubal sterilization has evolved significantly since it was first described, not only in surgical technique but also in cultural context. The first described procedure was performed by Samuel Smith Lungren in 1880 after a second cesarean delivery. In “tying both fallopian tubes with strong silk sutures about 1 inch from the uterus,” Dr. Lungren likely prevented a future maternal death, given the excessive morbidity of laparotomy at the time. Although sterilization continued to be performed in conjunction with other surgeries, it was not routinely performed as the sole indication for surgery due to the continued morbidity and mortality experienced with laparotomy.

Changes in surgical technique have coincided with changes in both cultural and ethical approaches to fertility control. Although many women choose sterilization, making it the most used contraceptive method among married couples, many women have had their fertility choices disrespected. Women of color, developmentally delayed women, and incarcerated women have been victims of forced sterilizations. To minimize these breaches of autonomy, the Department of Health, Education, and Welfare developed regulations around sterilization in the 1970s, including a written informed consent form and a 30-day waiting period. The federal Medicaid program still requires this documentation. Many have now come to question the utility of these policies, as they often serve as barriers to sterilization for the women they are supposed to protect, especially in the postpartum setting; however, many advocates for women also recognize the need for such policies. Because postpartum sterilization is one of the safest and most effective methods of contraception, the American College of Obstetricians and Gynecologists has recommended that these procedures be considered urgent, not purely elective. Sterilization can be performed with a minilaparotomy, or laparoscopically,

postpartum, or at an interval time. Many approaches are available in modern practice including tubal interruption, cautery, or salpingectomy (TABLE 18.1).

## TABLE 18.1
## Pregnancy Rates by Sterilization Method (Permanent and Reversible Methods)

| | 1-YEAR CUMULATIVE PROBABILITY OF PREGNANCY PER 1000 WOMEN | 5-YEAR CUMULATIVE PROBABILITY OF PREGNANCY PER 1000 WOMEN | 10-YEAR CUMULATIVE PROBABILITY OF PREGNANCY PER 1000 WOMEN |
|---|---|---|---|
| Postpartum partial salpingectomy | 0.6 | 6.3 | 7.5 |
| Hulka clip | 6.9 (combined) or 9.5 (just L/S) | 31.7 | 36.5 |
| Filshie clip | 1.1 (combined) or 1.9 (just L/S) | | |
| Silicone band | 5.9 | 10 | 17.7 |
| Monopolar coagulation | 0.7 | 2.3 | 7.4 |
| Bipolar coagulation | 2.3 | 3.2 | 24.8 |
| Bilateral salpingectomy | Uncertain, thought to be almost 0 | Uncertain, thought to be almost 0 | Uncertain, thought to be almost 0 |
| Hysteroscopic microinsert placement | Uncertain; 1.5-2.5 | Uncertain; 1.5-2.5 | Uncertain; 1.5-2.5 |
| **LARC Methods** | | | |
| Hormonal intrauterine system | 0.2 | 5-11 | |
| Copper intrauterine device | 0.8 | 4 | |
| Hormonal contraceptive implant | 0.05 | 0.5 | |
| Vasectomy | 0.15 | 11.3 | |

LARC, long-acting reversible contraception.
Sources: Dominic, CREST/Peterson 1996, Peterson 1999, Munro, Cleary, Clark.

# PREOPERATIVE EVALUATION

Postpartum sterilization accounts for almost half of sterilizations performed in the United States, with 60% performed after vaginal delivery and 40% at the time of cesarean delivery. Many surgeons prefer to wait at least 6 weeks postpartum before performing an interval sterilization procedure. In the case of laparoscopy, this wait mainly allows for the risk of venous thromboembolism to return to baseline, ensures complete uterine involution (minimizing potential damage to the uterus on abdominal entry), and allows the enlarged vascularity of pregnancy to recede. Despite this common practice,

waiting until 6 weeks postpartum has not been evaluated rigorously to determine if it decreases surgical risks. Laparoscopic procedures can be performed concurrently with an abortion.

There are no absolute medical contraindications to sterilization, although procedural risks and medical history must be carefully assessed. With a mortality rate of 1-2 per 100 000 procedures, predictors of a complication include use of general anesthesia, previous abdominal or pelvic surgery, obesity, and diabetes. Additional factors to consider include respiratory disease and clotting history or medications that affect clotting parameters. For comorbidities that increase surgical risk, information about equally effective options should be discussed. Long-acting reversible contraceptives—namely, intrauterine devices and implants—offer contraceptive efficacy equal to that of surgical sterilization but with minimal risk. Although only effective for 3-12 years, these devices can usually be placed on the same day, allowing a woman to leave your office effectively sterilized. Vasectomy also offers a very effective option for couples desiring sterilization that carries very limited risks.

Ensuring that patients understand the permanence of sterilization is paramount, especially in young patients or those who have never had a child. Although sterilization regret is rare, risk factors reported in decades-old data include age under 30 at the time of sterilization, nulliparity, and change in partner status. There is no robust literature on contemporary factors predicting regret or characterizing those who elect to be child-free, even at a young age. Attempts at sterilization reversal are often costly, are not always covered by insurance, and may not result in pregnancy. After salpingectomy, reversal is not possible, and pregnancy can only be pursued through assisted reproduction. Women’s desires to control their fertility are an integral part of their overall health, and their autonomy should be respected, with sterilization requests met through a mutually agreed upon manner.

# TUBAL STERILIZATION PROCEDURES PERFORMED BY MINILAPAROTOMY

Tubal sterilization can be performed using open procedures in both the interval and postpartum settings. Minilaparotomy is generally used for women who are postpartum after vaginal delivery or for women undergoing interval sterilization when a laparoscopic approach is unavailable, contraindicated, or unsuccessful.

Major morbidity from tubal sterilization is uncommon but does occur and varies by surgical approach. Major morbidity, defined as a complication requiring additional intervention, includes bowel or vascular injury on abdominal entry, bleeding requiring a transfusion, or respiratory complications requiring extended monitoring or ICU admission. Major morbidity occurs in 0%-3% of all sterilization methods. Minor morbidity, defined as complications requiring no intervention, includes simple concerns such as postoperative pain or vaginal bleeding and occurs in 0.5%-12% of cases across all sterilization methods (**TABLE 18.2**).

## TABLE 18.2
## The Most Common Tubal Sterilization Procedures by Route

- Minilaparotomy
  - Modified Pomeroy procedure
  - Parkland procedure
  - Salpingectomy
- Laparoscopy
  - Titanium clips
  - Silicone band clips
  - Bipolar coagulation
  - Salpingectomy

# Postpartum Tubal Sterilizations

Postpartum tubal sterilizations are performed through small abdominal incisions and should take place within 48 hours of vaginal delivery or before postpartum uterine involution. The uterine fundus is usually palpable to the level of the umbilicus. A 2- to 3-cm infraumbilical, vertical, or semicircular midline incision is made in the abdominal wall, where the abdominal wall is thin and through which both tubes can be easily reached. After the incision into the abdominal cavity, small retractors such as Army-Navy retractors are used to enlarge the field of vision. The uterine fundus should be palpated, and the surgeon's fingers sweep across the uterine fundus to identify the uterine cornua on each side. The surgeon's fingers can then hook under the cornua on one side to elevate the fallopian tube into the surgical field. A small Babcock clamp is placed around the tube to elevate the midisthmic portion. Both Trendelenburg and right or left positioning can be used to help bring the tubes into view. A uterine manipulator is generally not needed for a postpartum tubal sterilization because the uterus is easily palpated and manipulated from above. A blunt tubal hook can also be used to elevate the tube through the incision. Atraumatic clamps are then used to walk the tube out to its fimbriated end, which must be visualized to confirm that a tubal segment has been correctly identified for ligation. The tube is then ligated using the modified Pomeroy or Parkland technique. It is also possible to place titanium clips or silicone ring bands or perform bilateral salpingectomy through the minilaparotomy incision; however, it is important to note that these procedures are associated with higher failure rates.

# Interval Tubal Sterilization

Interval tubal sterilization performed via minilaparotomy should start with assessment of uterine size by bimanual exam. If only local anesthesia is planned for the skin incision, a paracervical block should be placed prior to placement of the manipulator. A uterine manipulator can be placed in the uterus prior to the procedure to facilitate easy movement of the uterus. A 2- to 3-cm vertical or

transverse midline incision is made suprapubically, just above the uterine fundus. The fundus of the uterus is palpated through the minilaparotomy incision and the cornua identified. Like postpartum tubal sterilization, the tubes are elevated through the incision and fimbriae are identified. A small Babcock clamp should be placed around the tube in the midisthmic portion. Tubal occlusion is then achieved using modified Pomeroy or Parkland techniques; alternatively, bilateral salpingectomy may be performed. Instillation of intraperitoneal lidocaine directly to the fallopian tube during minilaparotomy, particularly if performed under local anesthesia, can lead to decreased postoperative pain.

Tubal occlusion requires closure of the lumen of the bilateral fallopian tubes using a technique that allows for fibrosis of the lumen and, when relevant, peritonealization over the exposed end of the lumen. For any laparoscopic or open method of tubal occlusion, it is necessary to first identify the tube and then follow it out to its fimbriated end to ensure proper identification and note any abnormalities of the tube that might affect the surgical approach desired.

If tubal occlusion is chosen, 1-2 cm of tube should be left at the cornua. This small amount of tube avoids the theoretical risk that pressure from uterine contractions could allow pressure from fluid in the uterus to create a tuboperitoneal fistula and therefore prevent tubal occlusion, subsequently leading to possible pregnancy.

# *Modified Pomeroy Procedure*

The Pomeroy technique was first described in 1930 by Bishop and Nelms, colleagues of Pomeroy. They stressed the importance of using absorbable rather than permanent suture. The original Pomeroy technique was described using chromic catgut suture. The “modified” Pomeroy procedure replaces chromic catgut with plain catgut suture.

For this method, a loop of tube is grasped in the isthmic portion with a small atraumatic grasper such as a Babcock. The tube is elevated, and a loop is created by ligating the base of the loop with a no. 1 quickly resorbable suture such as catgut or chromic. A second

suture is then placed similarly, slightly above or below the first. The sutures are cut long to allow for easy identification if any bleeding occurs. The mesosalpinx within the loop is punctured with scissors, and a 2-3 cm segment of tube is then resected from the superior portion of the loop using scissors. It is important to resect an adequate portion of tube from the loop created. The two cut ends of remaining tube should be inspected to ensure that tubal lumen is visualized, and hemostasis is achieved. Resecting too little can be ineffective if the section does not transect the tubal lumen. Resecting too much is less worrisome but can make it impossible to achieve surgical reanastomosis if tubal reversal is desired in the future. Leaving too small of a tubal stump in the suture can result in the tubes slipping out of the knot causing delayed bleeding. It is important that the ligating suture is secure enough to prevent immediate bleeding if it should slip, but not so tight as to cause strangulation of the tubal ends remaining that could necrose and form a fistula with the peritoneum leading to failure of the procedure. Using a rapidly absorbable suture such as plain catgut or chromic is important to ensure that the tubal ends will quickly separate from each other, have the opportunity to fibrose, and peritonealize, assuring tubal occlusion.

The modified Pomeroy method can also be performed laparoscopically. In this approach, an operative laparoscope is placed through the umbilical port, and a 5-mm suprapubic port is placed. The tubes are identified, and an endoscopic slipknot of plain catgut suture is introduced through the suprapubic port. An atraumatic grasper is placed through the operative channel of the laparoscope and used to guide the loop around the isthmic portion of the tube. The slipknot is then tightened, forming a knuckle of tube. Scissors are introduced through the operative channel of the scope and the suture cut. The loop is then grasped using graspers through the suprapubic port, and scissors through the operative channel are used to excise the loop of tube above the ligature. The loop is lifted out of the port, allowing for examination of the tubal segment and visualize tubal lumen (**FIG. 18.1**).

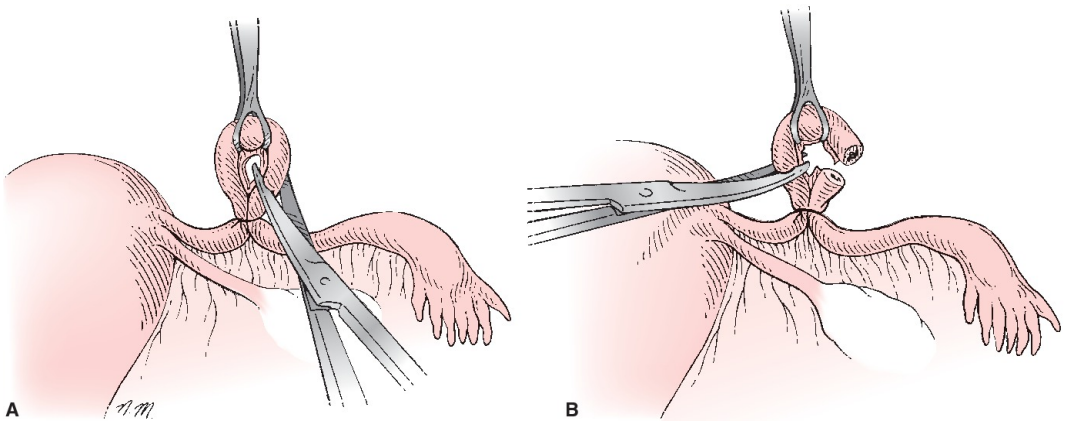



**FIGURE 18.1** Pomeroy method. **A.** A loop of the isthmic portion of the tube is elevated and ligated at its base with one or two ties of no. 1 plain catgut suture. If performed through a minilaparotomy incision, these ties should be held long to prevent premature retraction of the tubal stumps into the abdomen when the loop of tube is transected. **B.** A fenestration is bluntly created through the mesentery within the tubal loop, and each limb of the tube on either side of this fenestration is individually cut. The cut ends of the tube are inspected for hemostasis and allowed to retract into the abdomen.

## *Parkland Method*

This method was developed in the 1960s and made popular at the Parkland Memorial Hospital in Dallas, TX. In this method, the tube is elevated with a Babcock clamp in the isthmic portion. The mesosalpinx below the elevated tube is punctured with scissors or a hemostat, and a 2.5-cm window is created in the avascular

mesosalpinx beneath the tube. Two sutures are passed through the window in the mesosalpinx and tied both proximally and distally. A rapidly resorbable suture such as 0 chromic should be used. Once ligation of either end of the tubal segment is achieved, the intervening segment is resected. It is important to avoid putting too much traction on the ligated ends, which could result in tearing of the mesosalpinx and excessive bleeding. The ligated ends should be inspected for hemostasis (**FIG. 18.2**).

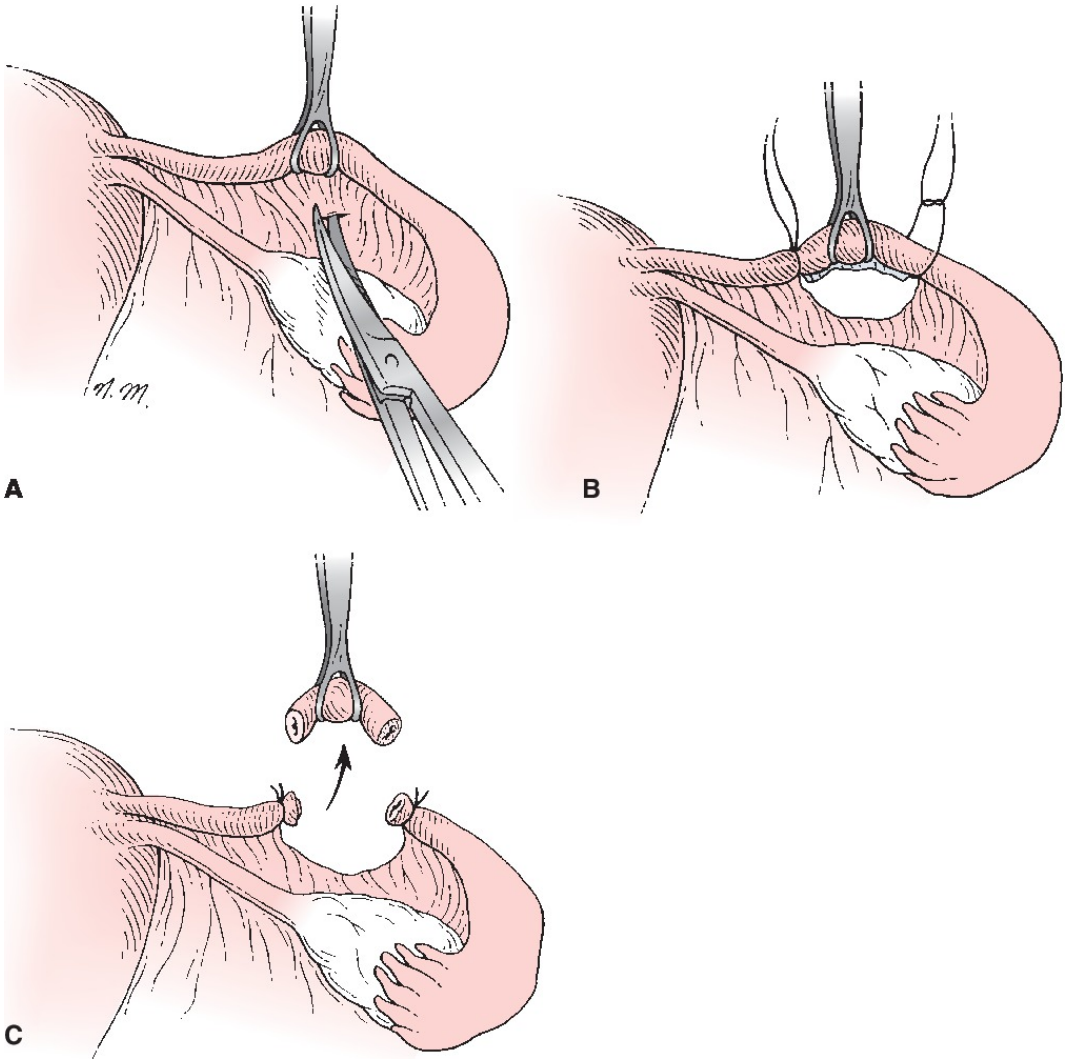



**FIGURE 18.2** Parkland method. **A.** A 2- to 3-cm fenestration is made beneath the isthmic portion of the tube either with scissors or

bluntly with a hemostat. **B.** Ligation of the tube. Pulling up on the suture during ligation or during transection of the tube can shear the tube off the underlying mesentery, resulting in troublesome bleeding. **C.** Portion of tube removed.

## *Uchida and Irving Methods*

Because of the concern of recanalization of the fallopian tube through the proximal stump of tube remaining after a resection of a tubal segment, several methods were developed to avoid this risk. The Irving and Uchida procedures were both developed to try to reduce this risk of tuboperitoneal fistula formation, which could contribute to failure of the sterilization. Both procedures involve extra steps to bury the proximal stump of the tube to prevent peritonealization. These procedures are performed much less often today, likely due to increased complexity. These procedures take longer and require more skill to perform, and the Irving procedure is associated with more bleeding. The effectiveness of sterilization does not seem to be improved with these more complicated procedures (**FIGS. 18.3 and 18.4**).

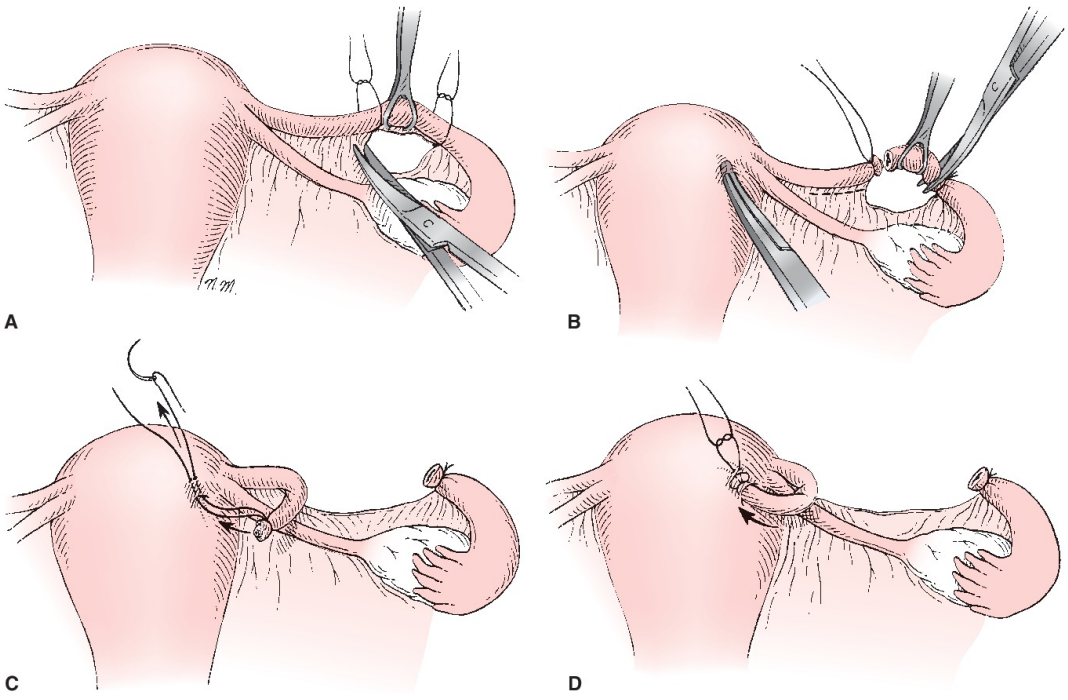



**FIGURE 18.3** Irving method. **A.** A fenestration is made beneath the tube about 4 cm from the uterotubal junction using scissors or a hemostat. **B.** The tube is then twice ligated, and a portion resected. A deep pocket is created in the myometrium on the posterior uterus. The *dashed line* shows the line of incision if added mobilization of the proximal tube is necessary to bury the end of the tube in the myometrium. **C.** The tagged ends of the tube are sutured deep into the myometrial tunnel and out through the uterine serosa. **D.** Tying these sutures secures the cut end of the proximal tube deep in the myometrial pocket.

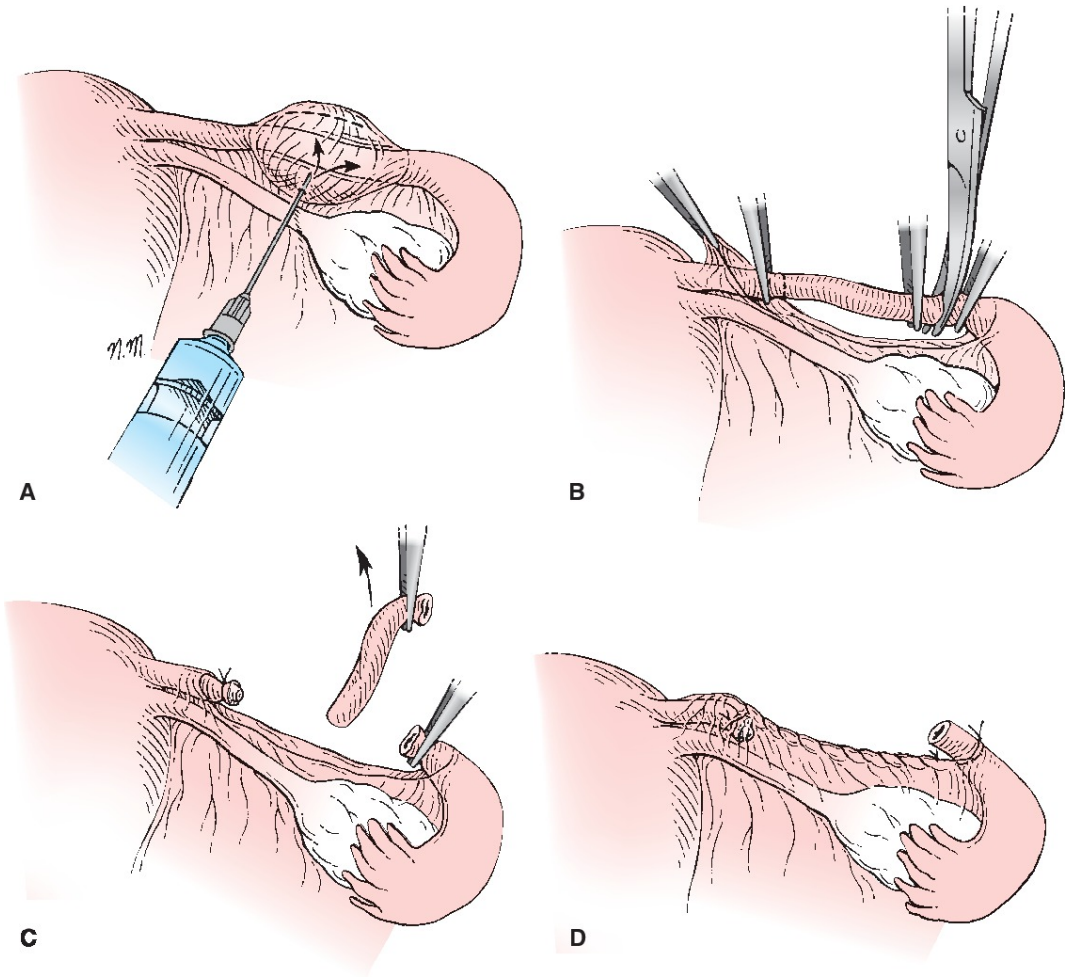



**FIGURE 18.4** Uchida method. **A.** An injection of vasoconstricting solution is given beneath the serosa of the tube about 6 cm from the uterotubal junction. The serosa is then incised (*dashed line*). **B.** The antimesenteric edge of the mesosalpinx is pulled back toward the uterus, exposing about 5 cm of the tube. **C.** The tube is ligated proximally and cut, and the tied stump is allowed to retract into the mesosalpinx. The hemostat on the distal stump remains attached to facilitate

exteriorization of this portion of the tube. **D.** The mesosalpinx is closed. A purse-string stitch of the mesosalpinx around the exteriorized tubal stump secures it in a position open to the abdomen, whereas the ligated proximal stump is buried within the mesosalpinx. Once the purse-string suture is tied, the hemostat can be removed.

## Complications Associated With Sterilization Performed by Minilaparotomy

Patients undergoing sterilization via laparotomy or minilaparotomy are at risk of complications inherent to laparotomy. These rare complications (bowel injury, vascular injury) are not specific to sterilization and are reviewed in more detail in the chapter on laparotomy. Given the superior safety of interval laparoscopic sterilization, sterilization performed by laparotomy or minilaparotomy should be undertaken at the time of cesarean section or in the early postpartum period. The complications most likely to be encountered include bleeding, need for adhesiolysis, and an inability to identify the tubes. Great care should be taken to find an avascular area in the mesosalpinx prior to any dissection. If bleeding occurs at laparotomy, given the likely good exposure due to the large incision, standard techniques (pressure, electrocautery, suture ligation, hemostatic agents) can be used to control it. Although maintaining a small incision is ideal for patient comfort and cosmesis, the ability to completely assess and manage any bleeding may require extending the incision.

Adherent tubes, especially in women with multiple prior cesarean deliveries, can pose significant challenges. At laparotomy, slow,

careful dissection will generally lead to adequate exposure to confidently identify the tubes. This is typically more of a challenge with procedures attempted with minilaparotomy, where exposure is limited. Tilting the surgical table to one side will allow the bowel to fall out of the surgical field, while the heavy uterus and attached tubes remain relatively midline, aiding in tubal identification. In obese women, exposure can be optimized by using appropriate retractors to maximize visualization. As with managing bleeding, extending a minilaparotomy incision is sometimes necessary, especially in obese women (**TABLE 18.3**).

### TABLE 18.3
### Complications from Minilaparotomy Procedures

| |
|---|
| Bowel injury |
| Vascular injury |
| Bleeding |
| Need for adhesiolysis |
| Difficulty mobilizing adherent tubes |
| Inability to identify the tubes |

## TUBAL STERILIZATION PROCEDURES PERFORMED LAPAROSCOPICALLY

Most interval tubal sterilization procedures in the United States are performed laparoscopically. The laparoscopic approach allows for clear visualization of both fallopian tubes and can be performed in women who have abdominal scarring from prior surgeries. To perform laparoscopic sterilization, the patient is most often under

general anesthesia. She is positioned with arms tucked at her sides if possible. Her body is secured on the operating table to allow for tolerance of a steep Trendelenburg position without slippage. A uterine manipulator should be placed in the vagina (a sponge stick) or uterus (a transcervical manipulator) to allow for movement of the uterus during the procedure. An entry site at the umbilicus is identified and infiltrated with local anesthetic such as 1% lidocaine or bupivacaine. The surgeon should use the abdominal entry technique of his or her preference, keeping in mind the patient's surgical history, and using a left upper quadrant entry when warranted. In most cases, a vertical or transverse incision is made at the base of the umbilicus using an 11-blade scalpel, and the abdomen is entered to initiate insufflation. Commonly a Veress needle is used for entry and there are other entry options.

Laparoscopy performed for tubal sterilization can be performed using one 5-mm incision in the umbilicus, with one to two 5-mm incisions in the right and/or left quadrants, or suprapubically. If using Filshie clips or Falope rings that can be placed through a single site applicator, only one 10- to 12-mm umbilical incision is needed. If bipolar coagulation is used, a second incision will be needed for this port. For bilateral salpingectomy, three 5-mm incisions are needed, one for the camera and two for instruments to manipulate and remove the tubes. Some advanced laparoscopic surgeons use a percutaneous port for one of the three port sites to improve cosmesis.

Intra-abdominal entry should be achieved in the manner most comfortable for the surgeon and appropriate to the patient. Once intra-abdominal entry is achieved and insufflation sufficient, the abdomen should be surveyed to assess that no injury occurred at entry and to identify the uterus, tubes, and ovaries. Trendelenburg positioning is used to bring the uterus and tubes into sight if they are blocked by the bowel.

# Bipolar Coagulation

Bipolar coagulation was described by Rioux and Cloutier in 1974. Bipolar coagulation can be used to occlude the fallopian tubes.

Electric energy flows between the two jaws of the grasper, cauterizing the tissue in the grasp. No distant return electrode is needed, as in monopolar coagulation. The field effects from the equal but opposite energy flowing from each side of the grasper cancel each other, and no capacitive coupling, which could lead to thermal spread, occurs.

With bipolar coagulation, bipolar forceps are introduced into the abdominal cavity through a 5-mm suprapubic or lateral port. The midisthmic portion of the fallopian tube is carefully identified and carried out to the fimbriated end. A transcervical or intravaginal instrument can be used to manipulate the uterus to obtain better exposure. The forceps are used to grasp the midportion of the fallopian tube, taking care to encircle the entire circumference of the tube and the portion of mesosalpinx below it. The proximal 2 cm of the tube should be avoided, to prevent tuboperitoneal fistula formation. The tube is tented toward the abdominal wall and away from any intra-abdominal structures. The tube is then cauterized three times over a 2- to 3-cm portion, until blanching and desiccation are noted. It is important to continue cautery until the device stops discharging, which indicates that there is no electrolyte solution in the tissue left to conduct the energy across the tube. This ensures that the inner portion of the tube is completely desiccated. Soderstrom and coworkers demonstrated that complete desiccation of the fallopian tube with bipolar systems is more successful when using a cutting waveform, with a power output of at least 25 W against a 100-V load as opposed to a coagulation or blended waveform (**FIG. 18.5**; **BOX 18.1**).

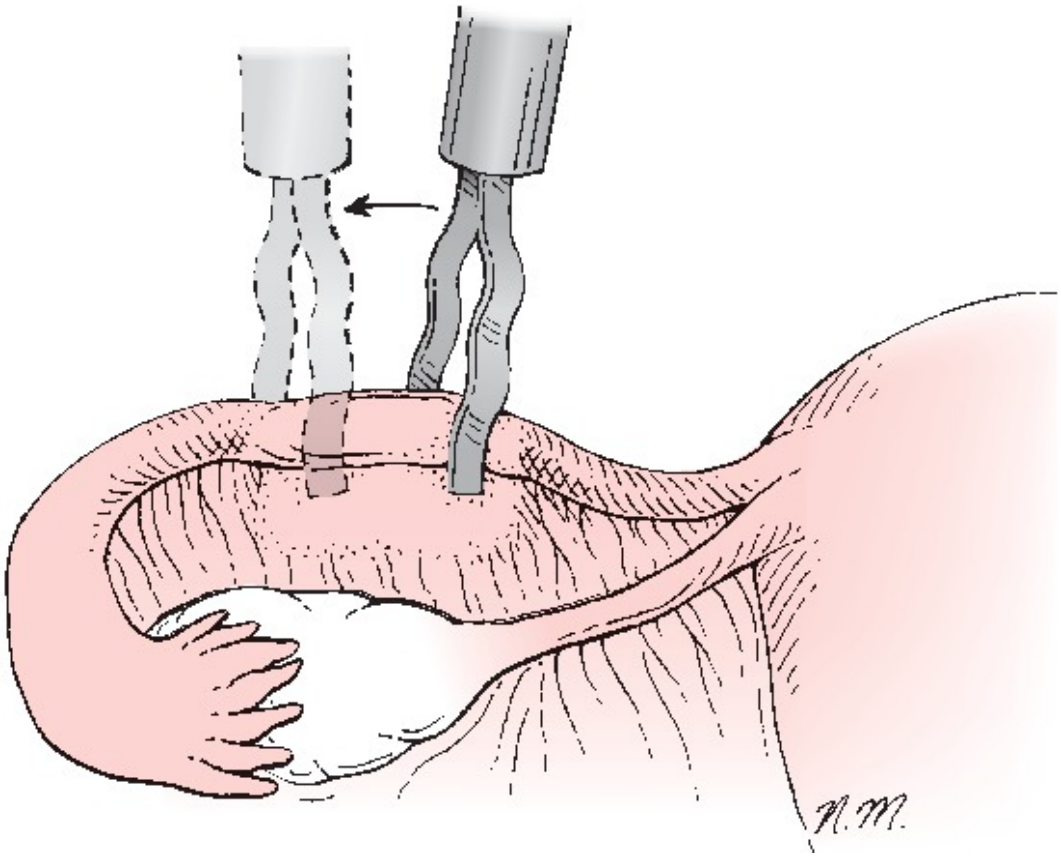


**FIGURE 18.5** Bipolar method. A 3-cm minimum zone of isthmic tube is desiccated with bipolar forceps. The paddles of the forceps extend across the tube onto the mesosalpinx.

## BOX 18.1 STEPS IN THE PROCEDURE

### Bipolar Coagulation

- Place in lithotomy position.
- Empty bladder.
- Drape perineum into sterile field.
- Enter the abdomen via minilaparotomy or laparoscopically.

- Display adnexal structures by displacing the uterus upward with cervical retractor.
- Identify the entire fallopian tube.
- Elevate tube at the midisthmic portion.
- Place 3 contiguous burns using bipolar forceps covering 2-3 cm of the tube, starting 2 cm from the uterine cornua and moving distally.
- Use bipolar device with at least 25 W cutting current.
- Dessicate tubal segment completely to ensure destruction of tubal lumen.

## Unipolar Coagulation

Unipolar coagulation, though highly effective, is less frequently used today because of the higher risk of injury to the bowel and other intra-abdominal structures. In unipolar coagulation, an insulated, specially designed grasper is introduced into the abdominal cavity. Because of the capacitive coupling that occurs in unipolar coagulation, a high level of electric energy can be discharged at any point in the patient's abdominal cavity or abdominal wall if the patient is not properly grounded (usually with a grounding pad on the patient's thigh). This leads to a much higher risk of both occult and overt injury. As much as 5 cm of tissue can be cauterized in one burn, and thermal spread can be difficult to detect.

## Nonthermal Methods of Tubal Occlusion

Concern for risk of injury from thermal methods led to the development of nonthermal occlusive methods for tubal sterilization. Silicone rubber bands, spring clips, and titanium clips were all developed in the 1970s to achieve sterilization without the use of electrocautery. These methods are performed laparoscopically

through an operative channel that allows for performing the entire operation through a single 10- to 12-mm port.

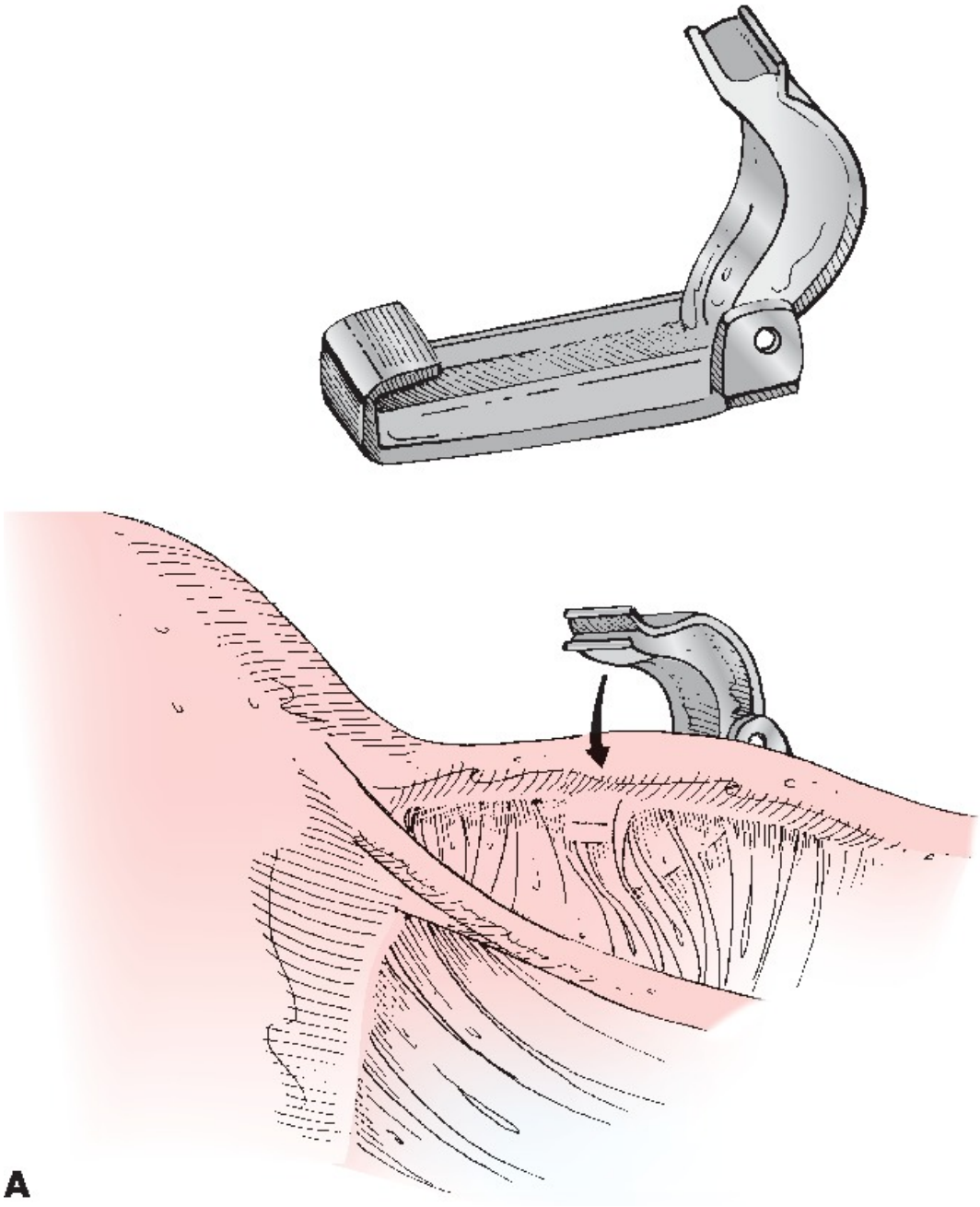
## *Spring Clips*

Invented in the 1970s by Hulka, and known as “Hulka clips,” these are 3-mm-wide gold-plated, stainless steel spring clips. Hulka clips were a popular choice for sterilization in the 1990s. They are not currently widely in use and are not available for use in the United States.

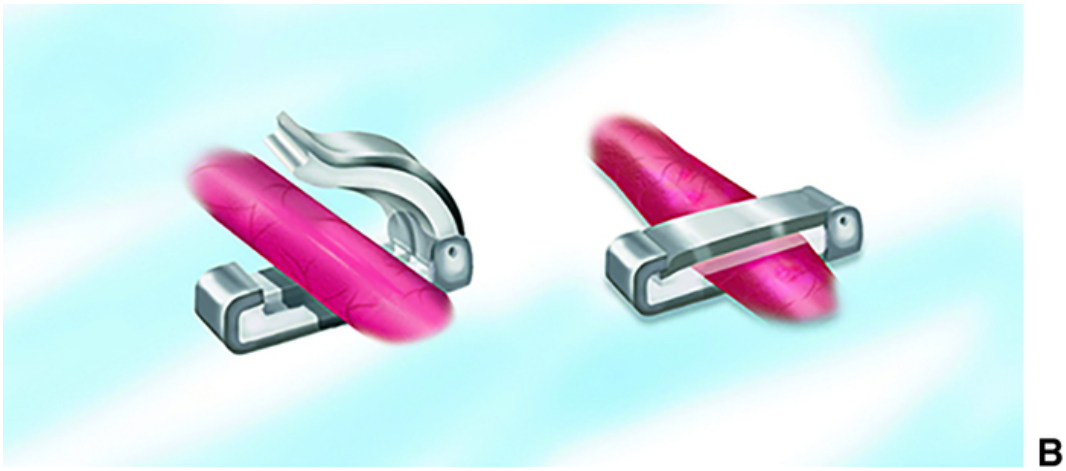
## *Titanium Clips*

Silicone-lined, titanium clips known as Filshie clips were first available in Europe in 1975. The hinged, Mark VI model was approved for use in the United States by the U.S. Food and Drug Administration (FDA) in 1996. These devices have titanium jaws lined with Silastic rubber. They are asymmetrical, with a longer lower jaw and shorter upper jaw. They are placed using a special applicator, which is available for both single-port and double-port placement. The clip is placed in the applicator, and the jaws of the clip are gently closed while the applicator is placed through the operative channel. A transcervical uterine manipulator is used to facilitate tubal placement. The clip is placed over the tube about 1-2 cm from the uterus, with care taken to include the entire circumference of the tube in the clip prior to closure. The tube is elevated using the clip on the end of the applicator. Because of the hinge and the silicone lining, the clip can be opened, closed, and adjusted along the tube to ensure proper positioning; however, once deployed, it cannot be removed. The longer jaw should be below and the shorter jaw above the tube. The mesosalpinx should be attenuated over the longer jaw prior to closure. Once the positioning appears correct, the applicator handle is squeezed tightly but gently to deploy the clip. This causes the shorter, upper jaw of the clip to flatten and lock into place. Use of too much pressure can result in transection of the tube. Once the clip is deployed, it cannot be opened again. If improper placement is noted, a second clip should

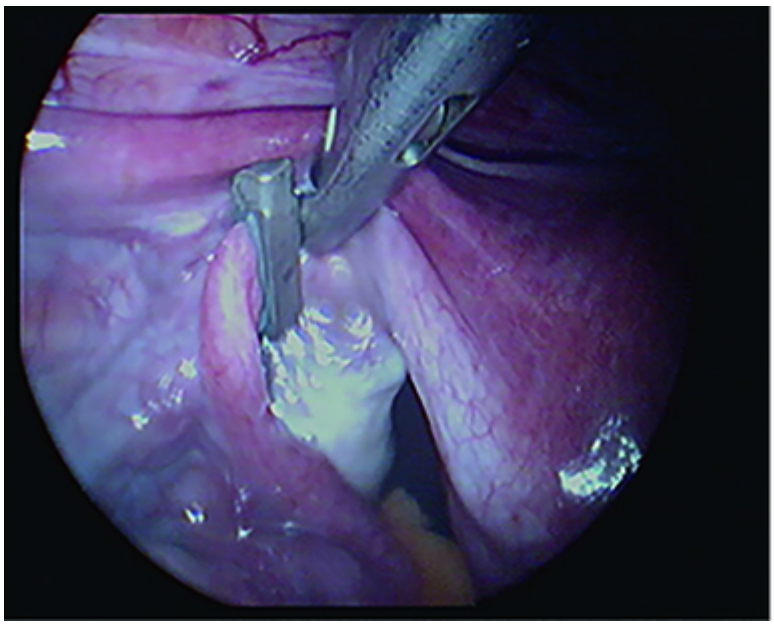
be deployed, leaving the malpositioned clip in place. Similarly, if the tube is transected, a clip can be placed on each transected end. After closure, both the tube and the silicone rubber lining of the clip are compressed. Over time, ~3-5 mm of the compressed tissue undergoes avascular necrosis, and the compressed silicone rubber expands. Eventually, attenuation and fibrosis of the adjacent tubal segments occur, and the clips are peritonealized. Similar to the spring clip, titanium clips work best with normal tubes. Tubal dilation, adhesions, and other abnormalities can make it difficult to place the clips or ensure proper tubal occlusion (**FIG. 18.6A-C**).



A



B



C

**FIGURE 18.6** **A.** Filshie clip method. The clip is applied to the midisthmus (~1-2 cm from the cornua) with the lower jaw of the clip being visible in the mesosalpinx to assure that the entire circumference of the tube is included. **B.** Illustration of Filshie clip applied to tube. **C.** Photo of applied Filshie clip with applicator. (**B, C.** Courtesy of Femcare Ltd.)

# *Silicone Band*

The silicone rubber band was developed by Yoon and colleagues in the 1970s. The band is introduced with a specially designed endoscopic applicator that can be placed through either the operating channel of a laparoscope or a separate second port. Immediately prior to entering the abdominal cavity, the band is stretched over the distal end of the applicator barrel. A transcervical uterine manipulator is used to maximize exposure of the fallopian tube. After the device is introduced into the abdominal cavity, grasping tongs are extended from within the applicator barrel. The tongs are used to gently hook and elevate the isthmic portion of the tube 3 cm from the uterus, being careful to ensure that the entire circumference of the tube is within the grasp. The tongs then are retracted into the applicator, which closes both arms of the tongs around the grasped tube while pulling the loop of tube up into the barrel of the applicator. The surgeon must take care to ensure that the tube continues to be completely encircled by the tongs as they are retracted into the applicator. Failure to do this can result in a band that does not fully occlude the lumen or is applied only to the mesosalpinx. It is important to avoid excessive traction on the tube during retraction of the tongs. The surgeon should slowly advance the entire applicator toward the tube while gradually retracting the tongs and tube up into the applicator, to avoid laceration of the mesosalpinx and hemorrhage or tubal laceration. Once the loop is fully retracted into the device, the band is slid off the applicator barrel and onto the base of the loop; 1.5-2 cm of tube should be contained in the constricted loop. The constricted loop appears blanched immediately after occlusion. After devascularization, this portion of the tube becomes anoxic and resorbs over time. Eventually, the band no longer encircles any tube and is later often found in the mesosalpinx. Apart from the 2-cm loop of encircled tube, very little destruction is caused by the band. It is difficult to apply a band to edematous or thickened fallopian tubes successfully. Tubal adhesions can reduce the mobility of the tube and preclude pulling an adequate loop of tube into the applicator. Additional bands can be applied to the cut edges if excessive bleeding occurs from

inadvertent tearing of the mesosalpinx or transection of the tube. Bipolar or unipolar coagulation can be used to obtain hemostasis or if clips cannot be properly placed due to tubal abnormalities (**FIG. 18.7**).

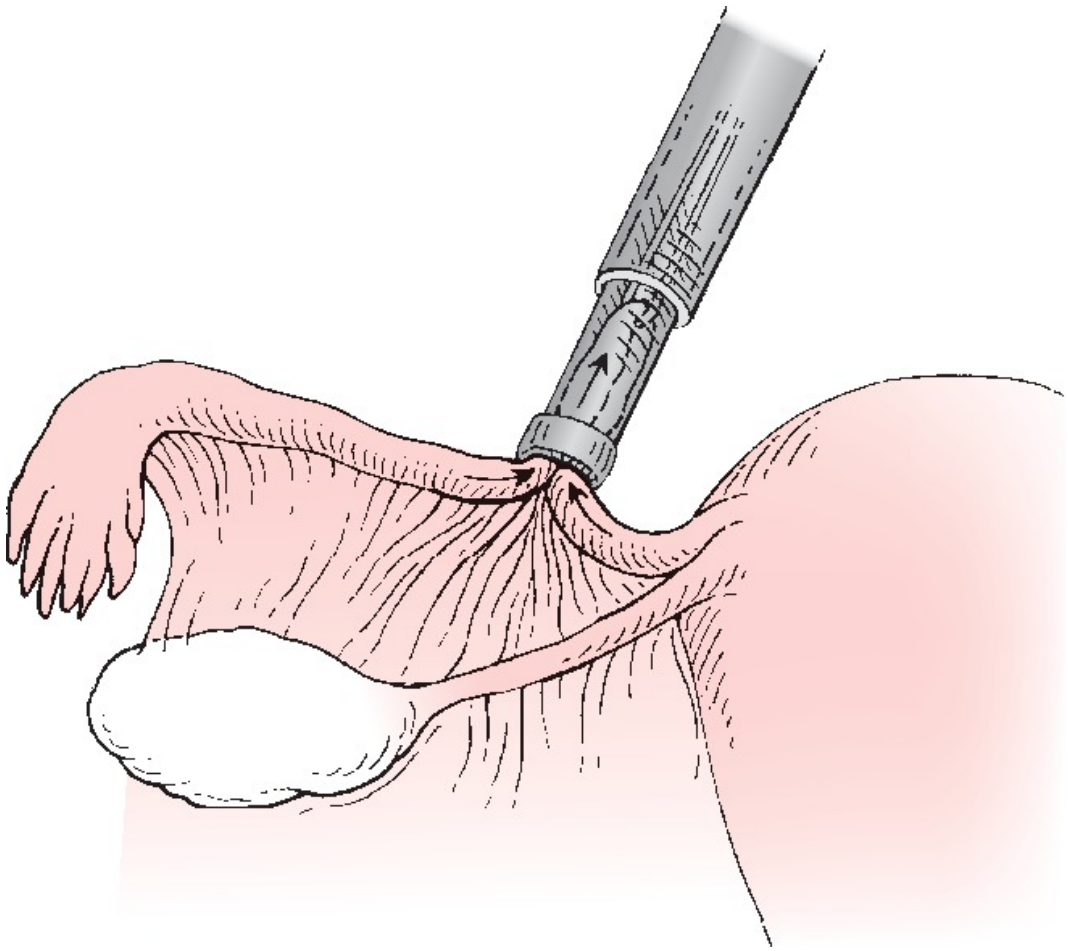


**FIGURE 18.7** Silicone band method. The isthmic portion of the tube is retracted into the applicator barrel using grasping tongs, which should completely surround the tube. The applicator barrel is advanced toward the tube during this retraction process to avoid

excessive traction on the tube and its mesentery.

## Complications Associated With Laparoscopic Sterilization

Patients undergoing laparoscopic sterilization procedures are at risk of complications inherent to laparoscopy. The most common of these are bleeding, adherent tubes, inability to place clips, or dropping a clip in the abdomen.

Tubal bleeding, which occurs in <1% of procedures, can be encountered when using any of the tubal occlusion devices. The ring band applicator has sharp prongs similar to a single tooth tenaculum used for grasping the tubes. Tubal serosal bleeding typically occurs as the tube is grasped and often resolves once the ring has been placed and deployed. If tubal bleeding continues after ring application, direct pressure can be applied using a laparoscopic peanut or electrocautery, taking care to elevate the tube away from surrounding structures. Similar bleeding can occur after application of the Filshie clip, which has sharp corners. This is typically a superficial serosal injury and does not usually require intervention.

Adherent tubes can also complicate laparoscopic sterilization procedures. Thorough review of surgical, medical, and infectious history prior to surgery can help minimize the chance of surprises at laparoscopy but will not completely predict finding adherent tubes. When adherent or enlarged tubes are encountered, one can change the surgical approach starting at the cornual end as opposed to at the fimbriated end. If pelvic anatomy is grossly distorted, performing intraoperative chromopertubation with methylene blue can identifying scarred or grossly adherent tubes. On occasion, altering the procedure is the safest way to lead to sterilization. If salpingectomy would require extensive dissection that might lead to bleeding or bowel injury, choosing a different sterilization method (clip, ring, or electrocoagulation) may be a better option. Ideally, this possibility is reviewed with the patient prior to her procedure.

If the tubes are grossly dilated, they may be too large to fully occlude using a Falope ring or Filshie clip. Surgical options at that point depend in part on preoperative conversations. In patients stating a clear preference to wake up from anesthesia sterilized but an openness to exactly how that is done, the procedure can most likely still be completed. Although the Falope ring applicator poses challenges with a dilated tube, a clip applicator will generally still work, although two clips may need to be applied to ensure that the entire width of the tube is occluded. If the surgeon thinks the tube is too large for use of clips, it may be more appropriate to consider electrocoagulation or salpingectomy, because of the risk of future complications from development of hydrosalpinx. In the postpartum setting where tubes are still enlarged, the clip has been shown to be less effective than partial salpingectomy, and similar concern should be taken into consideration with clip application performed in the interval setting.

On occasion, while attempting placement a clip will drop into the abdomen. This frustrating complication can usually be resolved by slow, methodical searching. If the clip was dropped during a placement attempt, it is most likely to fall into the posterior cul-de-sac. If it is somehow dislodged on entry into the abdomen, depending on the port site, the clip may be harder to find within loops of the bowel. A key point is to watch it fall and not reposition the patient until you have identified its location and have appropriate instruments available. Many surgeons perform single-incision clip application through an umbilical port, so there may be a need to insert an additional port to assist with bowel retraction, etc. However, if the clip is easily visualized, a grasper can be quickly placed through the operative channel to remove it. If the clip is not immediately visible, an x-ray can be ordered to determine its location. Placing the patient in reverse Trendelenburg can also help drop the clip into the cul-de-sac where it is easier to find. Most surgeons prefer removal of a dropped clip; however, there are reports of clips left in the peritoneal cavity without resulting in serious sequelae (**TABLE 18.4**).

## TABLE 18.4
## Complications From Laparoscopic Procedures

| |
|---|
| Bowel injury |
| Vascular injury |
| Bleeding |
| Need for adhesiolysis |
| Difficulty mobilizing adherent tubes |
| Inability to identify the tubes |
| Failure to occlude the entire tube with clip or band |
| Grossly dilated tubes that do not allow for clip or band placement |
| Clip or band dropped in the abdomen |

# HYSTEROSCOPIC TUBAL OCCLUSION

Desire to avoid abdominal surgery led to the development of a hysteroscopic approach to tubal occlusion. In 2002, the FDA approved the Essure microinsert, commercially known as Essure. These were nickel-plated titanium coils that could be placed hysteroscopically in the fallopian tubes. This product was removed from the market in the United States in 2018 due to risks associated with the device, including persistent pain, perforation of the uterus and fallopian tubes, and migration of the coils into the abdomen and pelvis. Women with successful Essure placement can continue to use them. Those with persistent pain or adverse outcomes should consult their physician to discuss appropriate steps such as removal or hysterectomy.

# BILATERAL SALPINGECTOMY

In recent years, performing bilateral salpingectomy, or “opportunistic salpingectomy,” has become more common for achieving female sterilization. Evidence that most ovarian cancers originate in the fimbria of the fallopian tube has made this an attractive option at the time of hysterectomy, oophorectomy, and tubal sterilization. Although the overall risk of ovarian cancer in the general population is very low, it is the leading cause of death from gynecological malignancies, accounting for over 20000 new cases and 13000 deaths in 2022. This is in part because ovarian cancer is notoriously difficult to detect in early stages. Multiple strategies for screening and early detection have been unsuccessful; therefore, preventive strategies are warranted.

Additionally, and perhaps more importantly, bilateral salpingectomy confers greater contraceptive efficacy than tubal occlusion methods. Fertilization occurs in the fallopian tube; therefore, removal of the tube significantly reduces the risk of any pregnancy significantly. The failure rate of all tubal occlusion methods is 18.5 per 1000 procedures over 10 years. Bilateral salpingectomy is recommended as appropriate management for women who have experienced pregnancy after tubal occlusion, suggesting that it confers better protection from pregnancy. There have been no long-term studies of contraceptive efficacy with bilateral salpingectomy; however, the U.S. Collaborative Review of Sterilization (CREST) study showed that excisional procedures of the tube were more efficacious than occlusion procedures, which might strengthen the proposal that excising the whole fallopian tube could confer even more efficacy. A systematic review including 39 studies found only 4 case reports of spontaneous pregnancy after bilateral salpingectomy and all pregnancies were intrauterine. Several cases of interstitial and heterotopic ectopic pregnancy after *in vitro* fertilization following bilateral salpingectomy have been reported; however, these involved embryo transfer, not spontaneous fertilizations. Removal of both fallopian tubes likely also reduces the risk of future ectopic pregnancy and hydrosalpinx, which can both cause pain and other morbidities. Unlike tubal occlusive techniques,

salpingectomy is feasible even with damaged or diseased tubes. Tubal reanastomosis for reversal of sterilization is not possible after bilateral salpingectomy; however, *in vitro* fertilization remains an option for women who desire pregnancy after sterilization.

A consideration when performing bilateral salpingectomy is the potential for disruption of ovarian blood flow, leading to premature menopause. Studies evaluating ovarian reserve after bilateral salpingectomy generally have not found any significant differences after salpingectomy; however, more data are needed on long-term outcomes. Salpingectomy can be performed at the time of cesarean section, postpartum, or at an interval time (see **BOX 18.2**; **VIDEO 18.1**)

## BOX 18.2 STEPS IN THE PROCEDURE

### Bilateral Salpingectomy

- Place in lithotomy position.
- Empty bladder.
- Place uterine manipulator.
- Drape perineum into sterile field.
- Enter the abdomen via minilaparotomy or laparoscopically.
- Display adnexal structures by displacing the uterus upward with cervical maniipulator.
- Identify the entire fallopian tube.
- Carefully lift the fimbria at the distal end of the fallopian tube off the infundibular pelvic ligament.
- Use electrocautery or a bipolar cutting device to excise the fimbria.
- Continue to excise along the mesosalpinx just below the tube.
- Approximately 1 cm from the cornua, elevate the tube perpendicular to the uterus and transect.

- Remove the tube from the abdomen.

# Salpingectomy at Cesarean Section

Bilateral salpingectomy can be performed in place of bilateral tubal ligation at the same time intervals that female sterilization is offered. It can be performed at the time of cesarean delivery, immediately postpartum, or at an interval outside of pregnancy.

At the time of cesarean delivery, bilateral salpingectomy should be performed after closure of the hysterotomy. Studies have shown that despite theoretical concerns for more blood loss with a gravid uterus, bilateral salpingectomy at the time of cesarean delivery does not seem to increase blood loss or complications. A meta-analysis and systematic review of 9 studies evaluating 1274 participants found slightly longer operative times asociated with bilateral salpingectomy compared to excisional procedures, but no other significant clinical or operative differences.

To perform bilateral salpingectomy at the time of cesarean delivery, the uterus should remain externalized. If the uterus is not able to be externalized due to scarring or other concerns, the procedure can still be performed if the fimbriae are able to be visualized and mobilized. The fimbria should be identified and grasped with a Babcock or Allis clamp. The fimbriated end should be elevated off the ovary and grasped with a hemostat below the fimbria. Care should be taken to avoid disrupting blood flow to the ovary. The utero-ovarian ligament should not be transected, and the infundibular pelvic ligament should be identified and avoided. If desired, a second hemostat can be used below the first to give traction while first separating the distal section of the tube from the ovary. Electrocautery or use of another bipolar device should then be used to detach the fimbria off the ovary and then continue across the mesosalpinx toward the uterus. Once the tube has been excised to the level of the uterus, electrocautery should be used to transect the tube just before the cornua. A section of tube up to 1 cm can be left at the cornua. Hemostasis should be noted; if any bleeding occurs, suture or electrocautery can be used to contain it. After both tubes are excised and hemostasis is noted, the uterus should be replaced

in the pelvis and again checked for hemostasis prior to closure of the laparotomy incision.

## Postpartum Bilateral Salpingectomy

Concerns for vessel enlargement in the gravid uterus, potentially longer operative time, and more complications have made postpartum bilateral salpingectomy a less preferred procedure than postpartum bilateral tubal ligation. For postpartum bilateral salpingectomy, the technique for entry into the abdomen and identification of the tube is similar to postpartum bilateral tubal ligation. A 2- to 3-cm transverse or vertical incision should be made at the level of the umbilicus. Subcutaneous tissue should be dissected sharply or bluntly to the level of the fascia. The fascia should be incised with Mayo scissors, or a scalpel and the peritoneum entered bluntly or sharply. The uterus should be maneuvered externally by rotating the surgical bed and placing external pressure on the abdomen. The surgeon's fingers should sweep toward the uterine fundus and bring the uterine cornua into the field of view. A Babcock clamp can then be used to grasp the tube. A second Babcock clamp can be placed distally, and this is repeated sequentially to follow the tube to the fimbriated end. Once the tube is identified, it should be lifted into the incision using Babcock clamps on the ampulla and the isthmic portions. Several pedicles can be made in the avascular portions of the mesosalpinx just below the tube to allow for placement of a Kelly or hemostat beneath the tube. The tube can then be excised all the way to the fimbria using electrocautery. The uterotubal junction should be suture-ligated with polyglycan (Vicryl) and then transected. Alternatively, this junction can be ablated with electrocautery and then transected. Hemostasis should be noted; then the uterus can be manipulated to expose the other tube, and the same procedure is performed on the other side.

## Interval Bilateral Salpingectomy

Bilateral salpingectomy can be safely performed instead of tubal occlusion procedures for interval sterilization. Interval bilateral salpingectomies are most often performed laparoscopically. Three ports are usually needed: one for the laparoscope, one for the operating instrument, and one for an atraumatic grasper. Alternatively, two ports can be used if the laparoscope has an operative channel. Placement of a transcervical uterine manipulator can be helpful to maneuver the uterus and improve tube exposure. An atraumatic grasper is used to trace the tube out to the fimbriated end. The fimbriae are lifted off the ovary taking care to avoid the infundibular pelvic ligament and the utero-ovarian ligament. The atraumatic grasper should elevate the tube while placing the electrosurgical instrument between the fimbria and the ovary. Electrocautery with monopolar scissors or a bipolar device with cutting ability should be used to excise the fimbria. The tube should be manipulated to expose a “V” in the mesosalpinx below the tube. The mesosalpinx should be cut along the lower edge of the tube across to the uterotubal junction. The tube should then be elevated perpendicular to the uterus to allow for cautery and transection of the tube, at a distance approximately 1 cm from the uterus.

## Surgical Complications From Bilateral Salpingectomy

Excessive bleeding can occur during salpingectomy, especially in women with scarring from prior surgery or endometriosis. Bleeding can be encountered as the surgeon proceeds medially, from the fimbriated end of the tube, gently separating the tube from the ovary. Surgeons should be mindful about not leaving behind fimbrial tissue, which is thought to persist in 9%-16% of procedures, because the current thought is that cancer develops from this portion. Given the proximity of the utero-ovarian vessels, infundibulopelvic ligament, and collateral vessels, care must be taken to find the most avascular plane and minimize harm to the ovary. Ovarian function seems to be unaffected even with wide dissection of the mesosalpinx. Bleeding at the fimbriated end of the dissection can be managed with judicious

use of electrocautery. The other area of concern for bleeding during salpingectomy is at the cornua, where the tube enters the well-vascularized uterus. Careful identification of the uterotubal junction and attention to the location of the interstitial portion of the tube, which is routinely left behind in a salpingectomy, can help minimize bleeding. As with sterilization performed by electrocoagulation, many providers cauterize more than once at the uterotubal junction to ensure a well-sealed interstitial stump. Should bleeding occur that is not amenable to management with additional electrocautery or pressure, other options include applying topical hemostatic agents or injecting vasoconstricting agents into the surrounding myometrium.

# STERILIZATION EFFICACY

All methods of sterilization are much more effective than more commonly used short-term, user-dependent, reversible contraceptive methods. Oral contraceptive pills are the most frequently used method of reversible contraception in the United States; 9% of women will experience a contraceptive failure (ie, pregnancy) with typical pill use. This relatively high risk of an unintended pregnancy highlights the importance of offering permanent contraception to women who have completed their childbearing. It comes as a surprise to many patients that (1) sterilization is not 100% effective and (2) long-acting reversible contraceptives (intrauterine devices and contraceptive implants) have failure rates comparable to sterilization. The etonogestrel contraceptive implant has the lowest annual failure rate of any contraceptive method, at 0.05%. Annual failure rates for copper (0.8%) and levonorgestrel (0.2%) intrauterine devices are also low, making all three long-acting reversible contraceptive methods reasonable options for a woman considering sterilization but interested in a nonpermanent method.

The effectiveness of sterilization was most thoroughly studied in the mid-1990s when the Centers for Disease Control and Prevention undertook the U.S. CREST trial. This large, prospective, multisite trial of 10 685 women who underwent sterilization between 1978 and 1986 established the safety and overall effectiveness of sterilization via laparoscopy and minilaparotomy. This large trial provides the

best data on the long-term effectiveness of sterilization. Although numerous trials since CREST have evaluated sterilization effectiveness and safety, none has followed women for up to 14 years, as in the CREST trial. Effectiveness of sterilization varies greatly by type (**TABLE 18.1**). In the CREST trial, the overall risk of pregnancy was 5.5 per 1000 procedures at 1 year and 18.5 per 1000 procedures at 10 years. The lowest failure rate at 10 years was observed with postpartum partial salpingectomy (7.5 per 1000 procedures); the highest failure rate was associated with the Hulka clip (36.5 per 1000 procedures).

The clips evaluated in the CREST trial—Hulka clips—are no longer used today. These plastic clips used a gold spring lock mechanism to hold the clip closed around the tube resulting in the highest 5-year failure rate in the CREST trial (31.7 per 1000 procedures). The clips more commonly used today—the titanium and silicone Filshie clip—use an applicator with a lip to close the clip around the tube. This mechanism has resulted in much lower failure rates than the Hulka clip. A systematic review of more recent evidence reports a 1-year failure rate of 4 per 1000 procedures for the Filshie clip. In two randomized controlled trials directly comparing sterilization procedures performed with Hulka clips vs Filshie clips placed via minilaparotomy or laparoscopy, Filshie clips had a 1-year failure rate of 1.1 per 1000 procedures compared to 6.9 per 1000 procedures for Hulka clips. In a Finnish database study of 16 272 female sterilizations, the failure rate for Filshie clips was 2.5 per 1000 follow-up years.

An additional change in surgical technique that has led to improved pregnancy prevention is the evidence-based approach to tubal occlusion using electrocoagulation. Although sterilization with the use of monopolar energy was associated with the lowest failure rate in the CREST trial (5-year failure rate of 2.3 per 1000), it was also associated with a higher complication rate presumed secondary to the greater thermal spread from use of monopolar energy and resultant bowel injury. Using bipolar coagulation with appropriate energy (≥25 W) as well as attention to desiccating a 3-cm segment of tube at three locations results in a 5-year failure rate of 3.2 per 1000.

# STERILIZATION SAFETY

Aside from providing highly effective, permanent contraception, sterilization is safe. Complication rates are low and major morbidity is uncommon. In the United Sates, death attributable to sterilization is rare. Based on data from several decades ago, death from sterilizations performed in a US hospital was estimated to be one to two deaths per 100 000 procedures. Most of the deaths reported in this series were secondary to anesthesia-related problems (hypoventilation, cardiopulmonary arrest) as opposed to direct surgical complications. Several of these deaths were caused by sepsis from unintentional bowel injury associated with the use of unipolar electrocoagulation. Due to the known increased thermal spread and higher risk of bowel injury potentially resulting in sepsis, use of bipolar electrocoagulation is recommended if thermal occlusion is the sterilization method of choice. In a separate series of sterilization procedures in the United States, deaths were more common in women with underlying medical conditions. More recent data suggest improved safety, with a report of no deaths among 9475 women who underwent interval laparoscopic tubal sterilization. Similarly, in a European study of 27 653 women who underwent tubal sterilization via laparoscopy or minilaparotomy, no deaths were reported. A Cochrane review published in 2016 including over 13 000 women also reported no deaths. These recent studies confirm that surgical sterilization is very safe.

# LONG-TERM AND DELAYED COMPLICATIONS FROM TUBAL STERILIZATION

Long-term or delayed complications from tubal sterilization include failure (ie, pregnancy), regret with subsequent reversal, pain with or without menstrual changes (formerly referred to as poststerilization syndrome), and further surgery (hysterectomy or microinsert removal). Although the 1-year cumulative risk of pregnancy after

sterilization is often reported as ~5 per 1000 procedures, the actual risk is highly dependent on the type of sterilization performed and the woman's age at the time of her procedure.

The biggest trial evaluating this issue in the United States is also the CREST study. CREST results summarized in **TABLE 18.1** report that 1-year failure rates ranged from <1 per 1000 procedures (unipolar coagulation and postpartum partial salpingectomy) to 18.2 per 1000 procedures (spring clip application). However, at 10 years, cumulative failure rates range from 7.5 per 1000 procedures (unipolar coagulation and postpartum partial salpingectomy) to 36.5 per 1000 procedures (spring clip application). Failure was also noted to be much higher in younger women, who have more reproductive years following their procedures. For women 18-27 years old at the time of their procedure, the failure rate was as high as 54.3 per 1000 procedures (bipolar coagulation) compared to women who were 34-44 years old at the time of their procedure.

Although the CREST study provides the largest cohort in the United States from which we can make estimations about the risk of failure, significant changes in surgical practice (shift toward laparoscopy) and sterilization procedures (hysteroscopic tubal occlusion, salpingectomy, different clips) have occurred since its publication. Secondary analysis of bipolar coagulation procedures performed during the U.S. CREST shows that 5-year cumulative pregnancy risks were 19.5 per 1000 procedures from women sterilized from 1978 to 1982 but only 6.3 per 1000 for women sterilized from 1985 to 1987. These differences suggest that changes in surgical practice can account for substantial changes in failure rates. For women undergoing sterilization via bipolar coagulation, coagulating at three sites has been shown to improve effectiveness. If fewer than three sites are used, the 5-year cumulative probability of failure is 12.9 per 1000 procedures. However, if three or more sites are coagulated, the 5-year cumulative probability of pregnancy is similar to what is seen with monopolar coagulation (3.2 per 1000 procedures vs 2.3 per 1000 procedures).

Most pregnancies reported after sterilization are delayed; some are due to undetected luteal phase pregnancies present at the time

of the procedure. This is estimated to occur in 2-3 per 1000 procedures. The risk of an early, undetected pregnancy can be minimized by encouraging the use of effective contraception up until the time of the procedure. Performing procedures in the follicular phase of the menstrual cycle after obtaining a negative pregnancy test decreases the chance of unknowingly operating on a woman who is pregnant.

Pregnancies that occur after sterilization procedures are more likely to be ectopic when compared to women who have not had tubal surgery. Similar to failure rates, ectopic risk is also dependent on the type of sterilization procedure performed. In the CREST cohort, among women who experienced a sterilization failure (pregnancy), the highest proportion of ectopic pregnancies (65%) occurred in women who had undergone sterilization by bipolar coagulation, followed by interval partial salpingectomy (43%), silicone rubber band application (29%), postpartum partial salpingectomy (20%), monopolar coagulation (17%), and spring clip application (15%). The risk of ectopic pregnancy varied not only by sterilization method but by time since procedure, with risk increasing over time. When looking at all methods of sterilization, the proportion of pregnancies that were ectopic was three times greater at years 4 through 10 (61%) relative to the first 3 years (20%). After 10 years, all reported pregnancies were ectopic.

Ectopic risk varies by type of sterilization and age at sterilization; it is also individual to each patient and can be considered in both absolute and relative terms. For women who were not using any type of contraception prior to sterilization and with several risk factors for ectopic pregnancy, the absolute risk of ectopic pregnancy likely declines after a sterilization procedure. For women who conceive after undergoing any type of sterilization procedure, ectopic pregnancy needs to be high in the differential diagnosis.

Several decades ago, when concern about post–tubal sterilization syndrome was stronger, there was also concern about an increased rate of hysterectomy in women who had been sterilized due to pain or irregular bleeding. In the CREST trial, all women who had been sterilized, independent of age, were almost five times more

likely to subsequently undergo a hysterectomy relative to women of the same age whose partners had a vasectomy.

## MENSTRUAL CHANGES AFTER STERILIZATION

Historically, significant debate surrounded the possibility of a post–tubal sterilization syndrome. Although not well defined, post–tubal sterilization syndrome includes menstrual change with or without associated pain. Concerns about post–tubal sterilization syndrome came about in the early 1950s and were supported by studies in the 1970s reporting similar poststerilization symptoms. However, the literature regarding this syndrome had methodologic flaws that have largely discounted the possibility of this syndrome. More recent prospective trials in the United States found no differences in bleeding patterns between sterilized women and nonsterilized women when use of contraception is controlled for. Similarly, no significant differences in menstrual symptoms and patterns were found among women who underwent sterilization compared to those whose partners underwent vasectomy.

The pathophysiology behind possible menstrual disruption from older sterilization methods (not including hysteroscopic) was initially attributed to insults to ovarian function. There was concern that tubal occlusion could negatively affect ovarian blood flow. This has not been well documented through additional studies, although thie concern is resurfacing given the rise in salpingectomy procedures. Current data do not support a significant impact on ovarian function, but long-term studies are still needed to answer this question definitively.

## REGRET

Due to its permanence, the decision to undergo and then perform sterilization is one that patients and their providers do not take lightly. Although reversal options exist for all methods besides bilateral salpingectomy, these procedures are complicated, costly, and may

not result in the desired outcome. Understanding the potential for regret can help guide preoperative counseling but should not serve as a reason to restrict access to sterilization in well-informed patients. The ability to predict who will regret undergoing sterilization is limited, as regret often stems from unpredictable life circumstances.

Poststerilization regret can be based on individual patient characteristics (age), changes in a patient's social situation (remarriage, loss of a child), dissatisfaction from the procedure, or associated side effects. Estimates of poststerilization regret vary widely and have been reported to be as high as 28%, with regret increasing over time. At 3 years, only 4% of women reported regret; by 14 years, 13% of women reported regret. Interestingly, the 5-year cumulative probability of regret was similar between women who underwent tubal sterilization (7%) and whose partners underwent vasectomy (6%). Six percent of women in the CREST trial reported having contacted a health care provider about tubal reversal at least once since their procedure, but only 1% obtained a reversal.

## KEY POINTS

- Patients need to be well informed about all options for controlling their fertility, both permanent and reversible. Prior to consenting for surgery, women should be aware that vasectomy confers less risk than female sterilization and is equally effective although not immediately.
- For patients electing female surgical sterilization, a thorough review of medical and surgical history and risks can help guide decisions about specific surgical approach. Women should be informed about the noncontraceptive benefits of sterilization (ovarian cancer risk reduction) and possible impact on menses.
- For interval sterilization, laparoscopic sterilization is preferred over laparotomy or minilaparotomy, given the lower complication rate and faster recovery time. For women not desiring

salpingectomy, a single incision procedure can be performed if an occlusion device (Filshie clip or Falope ring) is used.

- Salpingectomy should be offered to all women desiring laparoscopic sterilization, as it has the lowest likelihood of failure, has likely no ectopic pregnancy risk, and potentially offers ovarian cancer reduction. Although operative time is slightly increased, given the lack of increase in complications, this could be considered the optimal choice.
- Sterilization by laparotomy or minilaparotomy should be reserved for the peripartum setting, due to increased risks of complications relative to interval laparoscopic sterilization. Conversations about postpartum sterilization plans should be discussed during prenatal care, with avoidance of delaying such discussion to admission for labor and delivery. Prior to any cesarean delivery, providers should again address sterilization plans, to confirm patient preferences. Although complicated (Uchida) and simple (Filshie clip) options exist for sterilization in the peripartum setting, partial salpingectomy via a modified Pomeroy or Parkland technique is recommended.

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# CHAPTER 19

# SURGERY OF THE OVARY AND FALLOPIAN TUBE

Sarah L. Cohen Rassier and Antonio R. Gargiulo

**Treatment of Benign Ovarian Masses**

Ovarian Cystectomy

Oophorectomy

**Adnexal Surgery for Fertility**

Surgery for Tubal Obstruction

Tubal Reanastomosis

Ovarian Transposition

Ovarian Diathermy

In order to perform operative procedures on the ovary and fallopian tube, a thorough knowledge of the relevant anatomy, including vascular supply and relationship to adjacent structures, is required (**FIG. 19.1**). The primary blood supply to the ovary (see FIG 1.33) is the gonadal or ovarian artery, which branches off the aorta inferior to the renal vessels and courses in the infundibulopelvic ligament (also referred to in as the suspensory ligament of the ovary). The ovarian vein, however, drains differentially into the inferior vena cava on the right and renal vein on the left. The fallopian tube, which is composed of an isthmic portion near the insertion into the uterine cornua, an ampullary midportion, and the infundibulum near the fimbriated end, derives its blood supply from both ovarian and

uterine sources. Of note, the vasculature from the uterine/hypogastric source that runs in the utero-ovarian ligament is an important site of collateral flow between the abdominal and pelvic circulation. As depicted in **FIGURE 19.2**, the adnexal structures are in close proximity to the ureter as it courses over the pelvic brim anterior to the bifurcation of the iliac vessels.

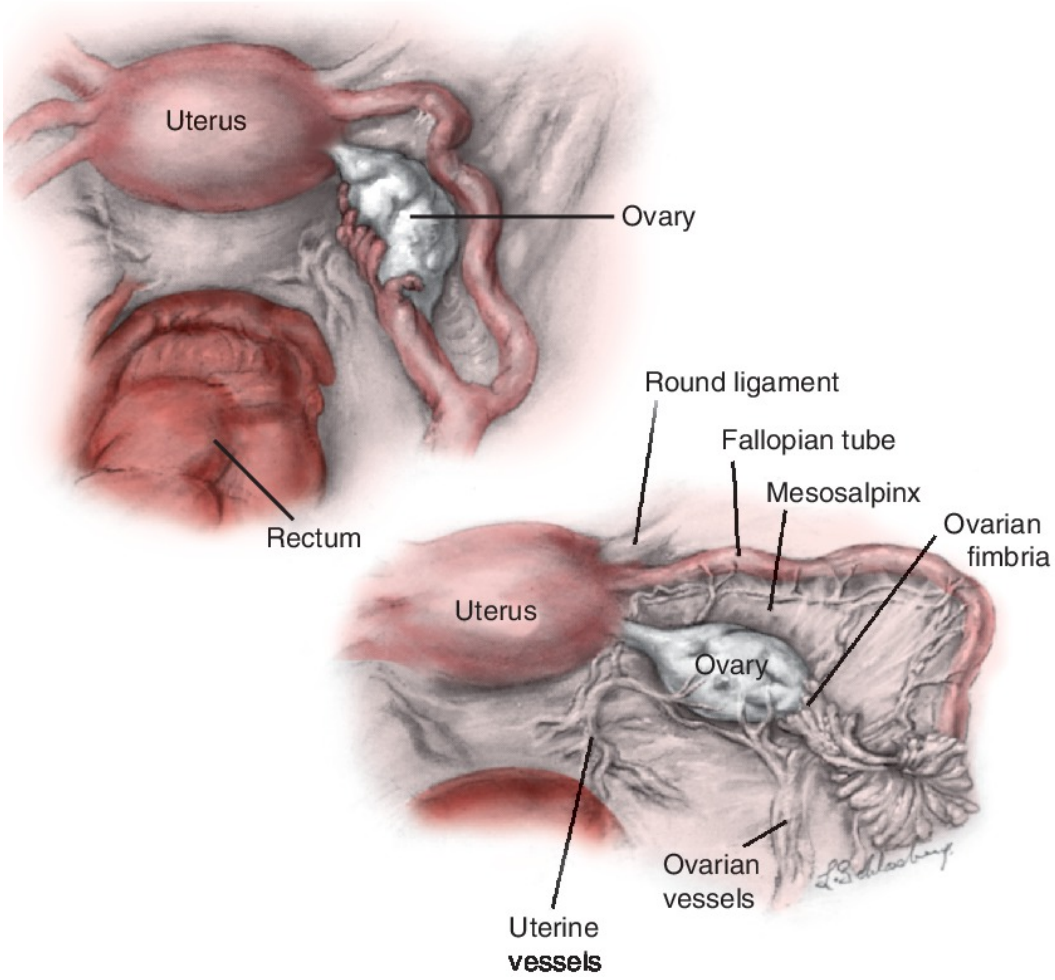



**FIGURE 19.1** Adnexal anatomy.

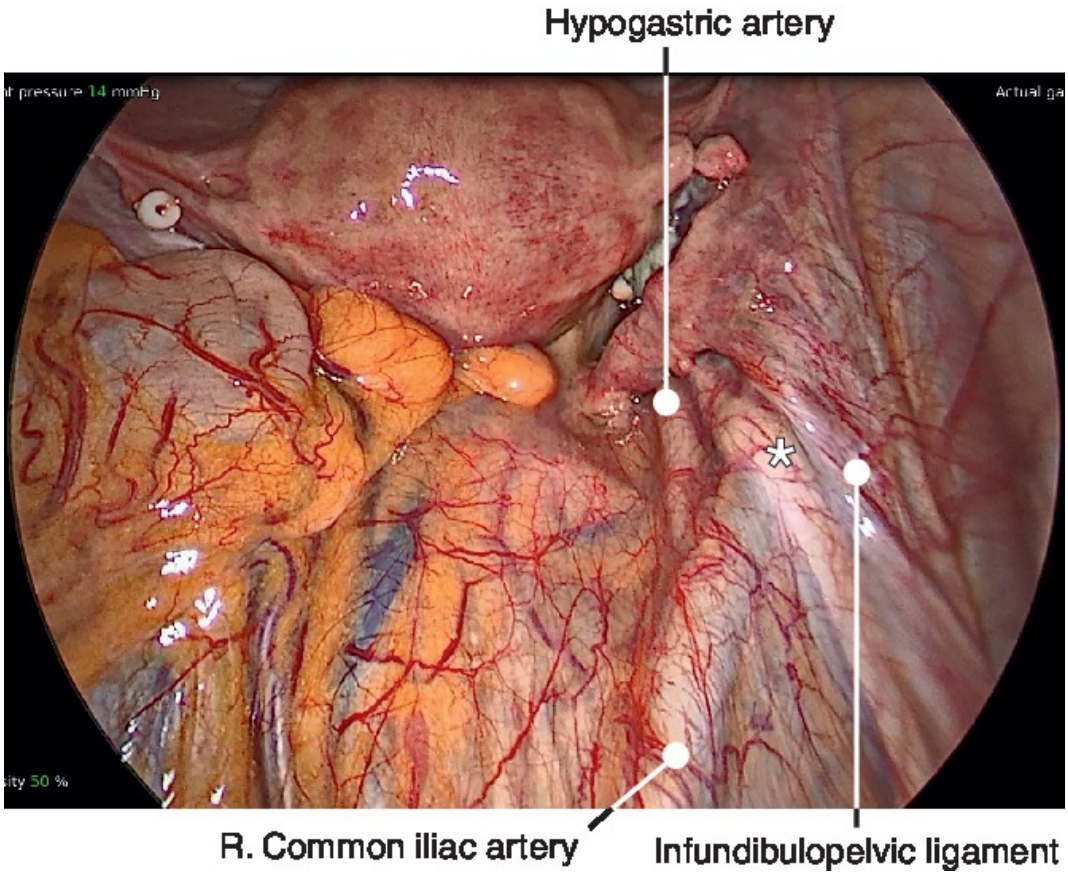



**FIGURE 19.2** Identification of ureter relative to gonadal vessels at pelvic brim. *Asterisk* denotes ureter coursing over external iliac vessels. (Courtesy of Dr. Sarah Cohen.)

Common indications for adnexal surgery include the presence of a mass, suspicion of torsion, or reproductive concerns. Regarding etiology of an ovarian mass, the differential diagnosis includes a physiologic ovarian cyst, such as a follicular cyst, corpus luteum, or hemorrhagic cyst, which may appear simple or complex in nature. Endometriomas, cystadenomas, fibromas, and dermoid cysts (teratomas) are other common benign adnexal masses that may be complex in appearance with varying degrees of solid components. Common masses of fallopian tube origin include paratubal cysts or hydrosalpinges. A malignant neoplasm must also be considered

when evaluating a pelvic mass, particularly in high-risk or postmenopausal women; certain imaging characteristics are helpful to distinguish benign from malignant masses.

Two circumstances in particular can result in an acute presentation requiring emergent operative management: ovarian cyst rupture or suspicion of ovarian torsion. In the case of a ruptured ovarian cyst, the patient may present with acute onset of abdominopelvic pain, exhibit peritoneal signs on physical exam, have free fluid documented on pelvic imaging, and, in contrast to the presentation of a ruptured ectopic pregnancy, have a negative hCG lab evaluation. Although a ruptured hemorrhagic cyst may be managed conservatively with pain control and supportive measures while awaiting self-resolution, operative management may be required to achieve hemostasis and clear the hemoperitoneum. A useful instrument for laparoscopic management of high-volume hemoperitoneum is a large-bore suction cannula; a 10-mm suction device allows for rapid clearance of blood and organized clot. Less commonly, an endometrioma, dermoid, or malignant neoplasm may rupture; these cases are typically managed surgically.

Ovarian torsion is characterized by acute onset of pain and nausea, typically along with the presence of an adnexal mass. Torsion may occur even in the setting of normal adnexa but is more common with an adnexal mass >5 cm in size. When torsion is suspected, urgent diagnostic laparoscopy is warranted to confirm diagnosis and to either detorse the adnexa or perform adnexectomy (as described below) if necessary. In the case of a premenopausal patient without suspicion of malignancy, adnexal conservation should be a priority unless there is evidence of grossly necrotic tissue; even ischemic/edematous ovarian tissue may regain function after detorsion. In cases of recurrent torsion, it may be beneficial to consider fixation of the ovary in an effort to prevent further recurrence. Oophoropexy can be accomplished by several methods such as plication of the utero-ovarian ligament or suture fixation to round/broad ligaments using delayed-absorbable suture. There are insufficient data to recommend one technique over another; however, it is imperative to avoid damage to ovarian blood supply or

anatomic relationship with the fallopian tube during such interventions.

In the vast majority of cases, a minimally invasive approach to adnexal surgery is preferred due to decreased perioperative morbidity and recovery advantages. Primarily, this encompasses laparoscopy or robot-assisted laparoscopy; however, adnexectomy can also be performed at the time of a vaginal hysterectomy or via natural orifice transvaginal approach. There are some limitations to minimally invasive modalities, however, and in some cases, laparotomy may be more appropriate. For example, when operating on an adnexal mass of extreme size, or when there is concern for rupture of a mass that is suspicious for malignancy, it may be preferable to approach the procedure via open abdominal technique. Minilaparotomy has also been described for the management of adnexal pathology and may be particularly useful in setting of large adnexal masses. In addition to basic laparoscopic instrumentation and electrosurgical devices, tissue extraction bags are often useful as will be described below.

# TREATMENT OF BENIGN OVARIAN MASSES

Treatment of presumed benign ovarian masses typically entails either ovarian cystectomy or oophorectomy. The decision of whether to conserve the ovary depends on many factors such as patient age, reproductive goals, characteristics of the mass, and its likely etiology. The primary contraindication for an ovarian cystectomy is a significant suspicion of malignancy, as ovarian cyst contents are often spilled at the time of cystectomy and could result in upstaging of the disease.

## Ovarian Cystectomy

It is critical when performing ovarian cystectomy to remove the entire cyst wall or capsule in order to prevent cyst reformation. Meticulous hemostasis should also be achieved, with care to avoid destruction

of normal ovarian tissue. The surgeon should recognize that modalities for achieving hemostasis may impact postoperative ovarian reserve. Bipolar desiccation appears to have the most detrimental impact on future ovarian reserve and should be avoided whenever feasible in favor of topical hemostatic agents or suturing. A variety of topical hemostatic agents are compatible for use with laparoscopic surgery, including oxidized regenerated cellulose and gelatin matrix-thrombin combination products. It is important for a surgeon to become familiar with each individual product's instructions for use, as some agents are designed to be left *in situ*, while others require the removal of excess material after a period of time. A dilute vasopressin solution (no more than 10 units total) can be injected into ovarian tissue between cyst wall and cortex prior to cystectomy in order to minimize bleeding and increase ease of dissection. This technique has shown promise in particular with dissection of endometrioma cysts. After cystectomy, suturing of the ovarian defect (typically with an absorbable 2-0 or 3-0 grade suture) is not routinely required unless hemostasis is a concern. The ovarian incision can be closed in interrupted or running fashion; alternately, a purse-string suturing technique can be utilized to reapproximate redundant tissue in the ovarian cyst bed.

The approach for ovarian cystectomy (**FIG. 19.3**) includes exposure of the adnexa and assessment of cyst location with reference to the ovarian hilum, vascular structures, and fallopian tube. Taking care to avoid undue thermal tissue damage, an electrosurgical tool is used to incise the ovarian tissue overlying the cyst. The location of this incision should be over the thinnest area of ovarian surface near the cystic prominence, avoiding normal ovarian cortex; the length of the incision depends on cyst size but is typically a minimum of 1-2 cm in length to allow for adequate exposure to cyst wall. The cyst contents can be intentionally ruptured and drained, which may be especially useful with large cysts to improve visualization and manipulation during cystectomy. In some cases, it is possible to maintain the cyst intact if the cyst wall separates easily from the underlying ovarian tissue during dissection; this approach may be particularly desirable in cases of dermoid cysts to avoid spillage of cyst contents (which can result in chemical irritation of the

peritoneal cavity). Gentle traction and countertraction should be applied along the cleavage plane between cyst and ovary, with attention to avoid tearing of the ovary due to excess force. Some cases may require sharp dissection (using scissors) as the cyst wall is peeled away from underlying ovary. Sharp dissection may be necessary for example in cases of ovarian endometriomas, when chronic inflammation leads to scarring between the cyst wall and normal ovary. Once the cyst has been separated from the ovary, the cyst bed should be carefully inspected to ensure all cyst wall and associated material has been removed. In addition to irrigating over the cyst bed, it can be useful to perform a low-pressure test to confirm adequacy of hemostasis during laparoscopic surgery. A low-pressure test is achieved by decreasing the insufflation pressure of carbon dioxide to between 5 and 10 mm Hg so that any small venous bleeding that may normally be occluded by higher intraperitoneal pressures can be readily identified. Use of thermal energy to enhance hemostasis should be minimized as discussed earlier. The specimen can then be placed into a specimen extraction bag and removed via an abdominal port site (**BOX 19.1**).

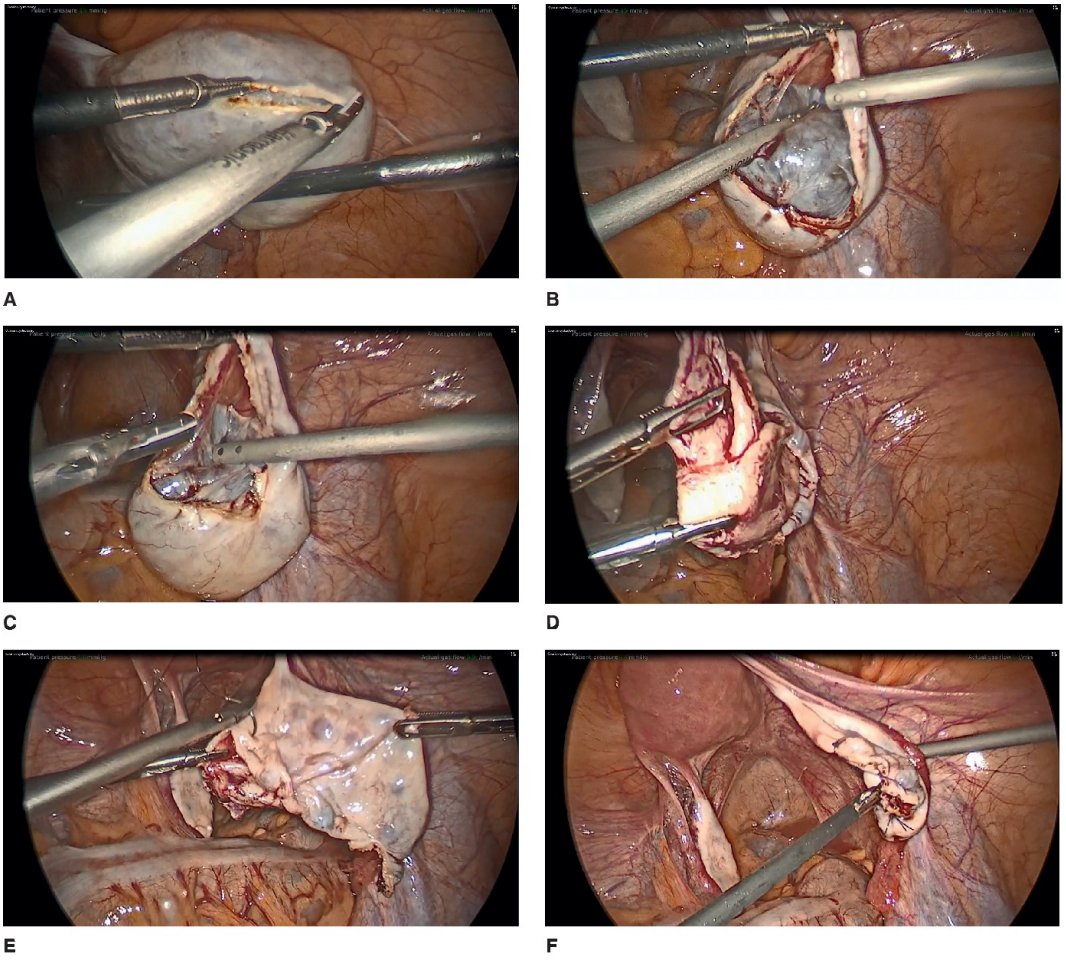



**FIGURE 19.3** Laparoscopic ovarian cystectomy. **A.** After exposure of the adnexa and assessment of cyst location, an incision is made overlying the cyst. **B.** The cyst wall is dissected from the surrounding ovarian tissue. **C.** Controlled rupture for drainage of the cyst contents. **D.** Gentle traction and countertraction applied along the cleavage plane between cyst and ovary. **E.** Suturing of ovarian cyst defect to enhance hemostasis and/or restore normal anatomy. **F.** Final view. (Courtesy of Dr. Sarah Cohen.)

## BOX 19.1 STEPS IN THE PROCEDURE

### Ovarian Cystectomy

- Incise ovarian tissue overlying cyst.
- Decompress cyst contents if needed.
- Dissect cyst wall away from underlying ovarian tissue using gentle traction and countertraction.
- Ensure hemostasis in ovarian cyst bed, avoiding thermal damage to ovarian tissue.

Depending on the type of ovarian cyst, additional aspects of surgical technique remain controversial. For example, in cases of endometrioma with difficult dissection or extensive scarring, some surgeons prefer to drain the cyst and fulgurate the cyst wall to minimize damage to normal ovarian tissue. However, the traditional cystectomy technique has been associated with reduced risk of recurrence and preferable effects on ovarian function compared to endometrioma ablation. Dermoid cysts also require special care due to the risk of peritoneal inflammation or chemical peritonitis with spillage of contents. To mitigate this concern, a containment bag may be used as an adjunct to laparoscopic cystectomy for dermoid cysts. With this technique, a surgical containment bag is introduced into the pelvis and positioned underneath the planned dissection site prior to incising the ovarian cyst (**FIG. 19.4**). A containment bag can be introduced via one of the abdominal port sites (most available products will easily fit via 10-mm or greater sized trocar) and can either be free-standing or attached to an introducer stick. The containment bag can also be introduced via a posterior colpotomy if desired; one approach involves introducing a laparoscopic trocar through the posterior cul-de-sac under direct laparoscopic guidance and then using this trocar to introduce the bag and perform specimen extraction. The containment bag serves as a tarp underneath the ovary to collect any ruptured cyst contents and

minimize spill. Of note, this is not intended for oncologic purposes but rather to contain potentially irritative substances from the cyst.

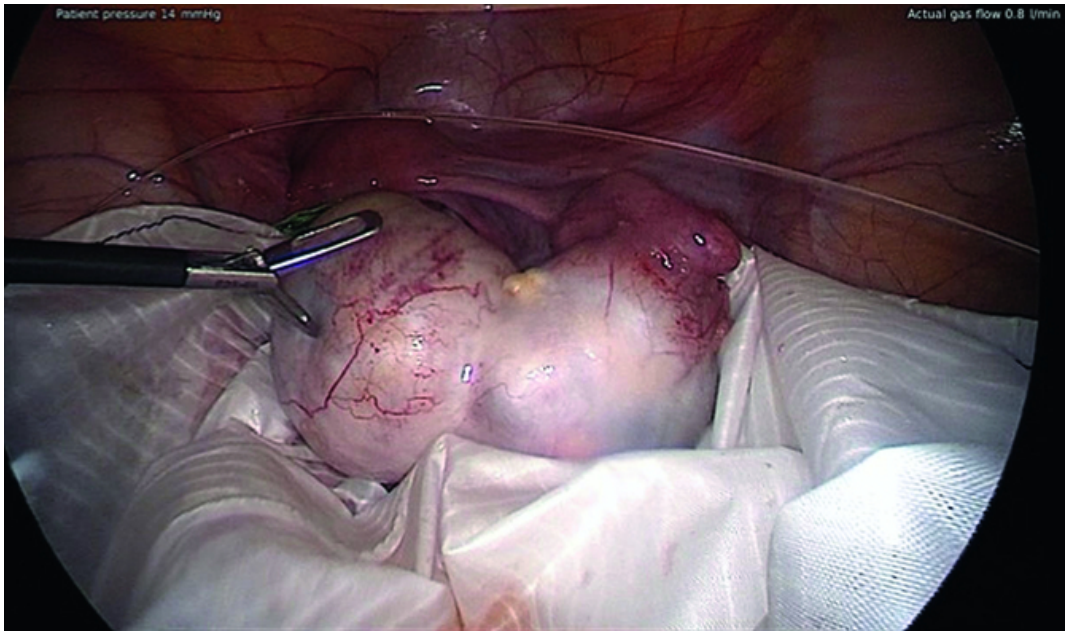



**FIGURE 19.4** Containment bag used at time of dermoid cystectomy. (Courtesy of Dr. Sarah Cohen.)

## Oophorectomy

Oophorectomy alone may be performed in cases of adnexal mass for similar indications described earlier and may also be performed concomitantly with hysterectomy. Due to the overlap in blood supply, the ipsilateral fallopian tube is typically removed along with the ovary (salpingo-oophorectomy). General principles include meticulous attention to location of the ureter relative to the adnexal dissection, control of vascular supply, and conscientious specimen extraction. Additionally, pelvic washings should be collected at the beginning of the case if there is a suspicion for possible malignancy to allow for complete surgical staging.

Salpingo-oophorectomy (**FIG. 19.5**) begins with identification of the ipsilateral ureter. In some cases, the ureter can be seen transperitoneally as it courses over the pelvic brim into the deep pelvis along the pelvic sidewall. If the ureter is readily visible and its course appears sufficiently distant from pertinent vascular and adnexal structures, a full ureterolysis is not required. However, in cases of limited visualization such as may be found with obesity, endometriosis, or adhesive disease, it is prudent to perform a retroperitoneal dissection to identify the ureter and isolate the gonadal vasculature. In order to accomplish this, the peritoneum is grasped and elevated so that a relaxing incision can be made with either sharp dissection or electrosurgical instrumentation. This relaxing incision can be made lateral to the infundibulopelvic ligament, opening the retroperitoneal space from level of round ligament to the pelvic brim parallel to the utero-ovarian-ovary-infundibulopelvic axis. Alternately, the retroperitoneum can be entered from a medial approach by incising the peritoneum over the pelvic sidewall along the paraovarian fossa from the pelvic brim down toward the uterosacral ligament. After opening the peritoneum, the avascular pararectal space is developed and gently explored using a push-and-spread technique until the ureter is identified peristalsing along the medial leaf of the broad ligament. A peritoneal window may then be created to isolate the gonadal vasculature prior to division of the infundibulopelvic ligament with either traditional method of suture ligation and cutting or desiccation and transection by electrosurgical device. The utero-ovarian ligament and its accompanying vasculature are similarly controlled and divided along with any remaining peritoneal reflections anchoring the adnexa to the broad ligament complex (**BOX 19.2**). If using a laparoscopic approach, the specimen is then placed into a specimen extraction bag and removed through an abdominal port site. Transvaginal specimen extraction via posterior colpotomy has also been described at the time of laparoscopic salpingo-oophorectomy. The posterior vaginal incision can be made from either the laparoscopic or vaginal approach; alternately, a trocar can be inserted into the posterior cul-de-sac under laparoscopic guidance in lieu of formal incision to access the peritoneal cavity. If the mass is cystic in

nature, it can be decompressed while inside the containment bag to allow for removal through a small incision. When removing a solid adnexal mass, it may be necessary to enlarge one of the skin sites to a minilaparotomy incision to facilitate specimen removal. Particularly in cases suspicious for malignancy, it is important to avoid intra-abdominal dispersion and minimize fragmentation of the specimen at time of removal to ensure the ovarian surface remains intact.

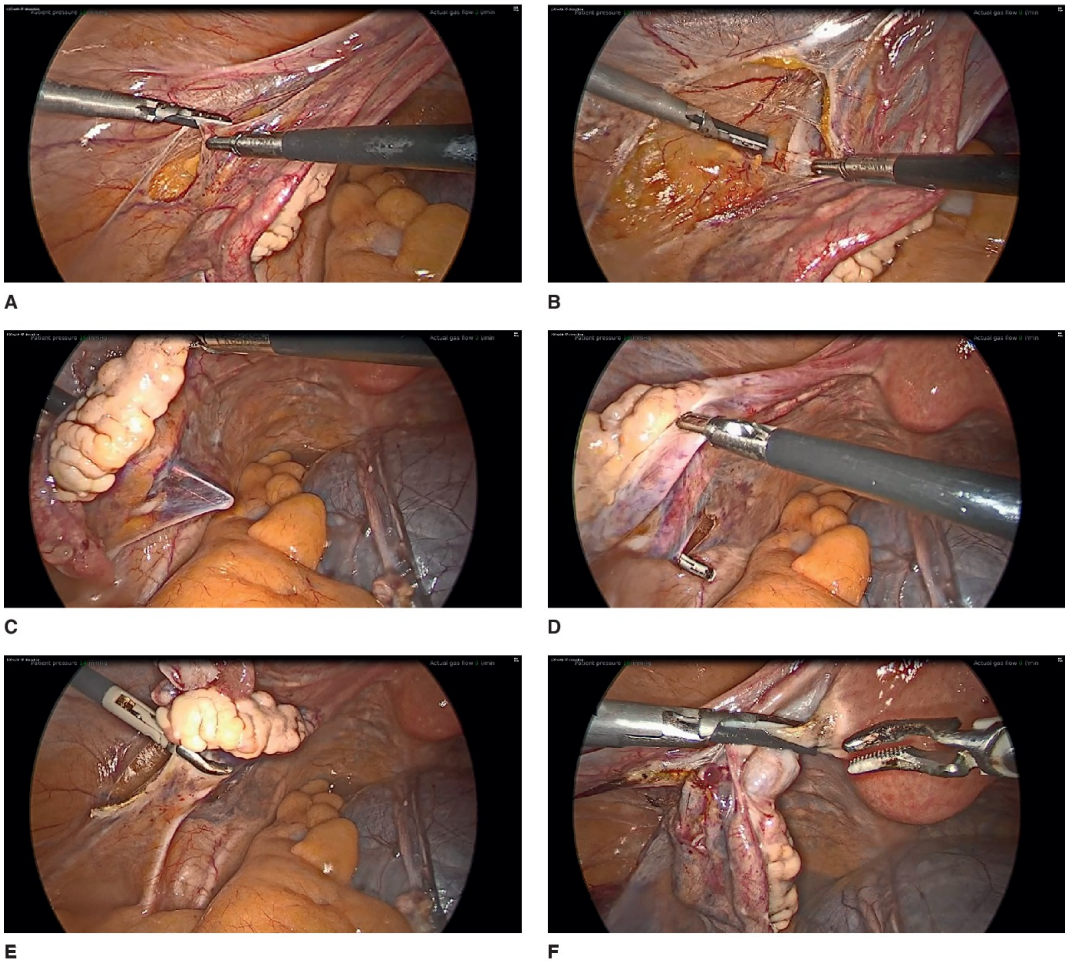



**FIGURE 19.5** Laparoscopic salpingo-oophorectomy. **A.** Following exposure of infundibulopelvic ligament, the peritoneum is incised lateral to infundibulopelvic ligament to

begin a retroperitoneal dissection. **B.** The incision is extended parallel to infundibulopelvic ligament, and a gentle spreading dissection technique used to identify the ureter in retroperitoneum. **C and D.** A peritoneal window is created in order to isolate the infundibulopelvic ligament. **E.** Electrosurgical transection of the infundibulopelvic ligament pedicle. **F.** Utero-ovarian ligament transected to complete adnexal removal. (Courtesy of Dr. Sarah Cohen.)

## BOX 19.2 STEPS IN THE PROCEDURE

### Salpingo-Oophorectomy

- Obtain pelvic washings if indicated.
- Expose infundibulopelvic ligament.
- Delineate ureter position, either transperitoneally or via retroperitoneal dissection.
- Divide gonadal vessels.
- Divide utero-ovarian ligament and fallopian tube at the uterine cornua.
- Excise adnexa by transecting any remaining peritoneal reflections.

When performing adnexectomy at the time of abdominal or laparoscopic hysterectomy, similar steps as described earlier are

undertaken, with the exception that division of the utero-ovarian ligament is not necessary. If salpingo-oophorectomy is planned at the time of vaginal hysterectomy, the ureter is first palpated along the pelvic sidewall prior to dividing the infundibulopelvic ligament. Although the ovaries are often accessible via vaginal approach, in situations with limited visualization or access, it may be prudent to proceed with laparoscopic assistance for adnexal removal. A variation involving natural orifice transluminal endoscopic surgery may facilitate this process without need for separate abdominal incisions. If salpingo-oophorectomy is performed following a prior hysterectomy, there may be adhesions present or loss of normal anatomic relationships, and it is particularly important to identify the ureter with retroperitoneal dissection as indicated.

One particular concern in cases of difficult salpingo-oophorectomy involves the development of an ovarian remnant. Ovarian remnant syndrome is characterized by onset of pelvic pain and an adnexal mass following adnexectomy. Additionally, in women who have undergone bilateral salpingo-oophorectomy, the presence of an ovarian remnant may be suggested by return of menstruation and confirmed by laboratory hormone level analysis. Factors predisposing to ovarian remnant include adhesive disease, endometriosis, or anatomic variation leading to a challenging primary procedure. If residual ovarian tissue is left behind at the time of salpingo-oophorectomy, it can proliferate and become enlarged or symptomatic. The primary method to avoid ovarian remnant surgery at time of the initial procedure involves adherence to good surgical technique and comfort with retroperitoneal dissection when required. When ovarian remnant syndrome is suspected, one option for confirmatory testing involves provocation with clomiphene citrate to stimulate cyst formation; imaging can then be performed to localize the remnant tissue and aid with surgical planning. Definitive management is surgical and often requires advanced retroperitoneal dissection to perform ureterolysis, isolate the gonadal vessels, and excise the residual ovarian tissue.

When a risk-reducing bilateral salpingo-oophorectomy is undertaken for familial breast and ovarian cancer syndrome or other high-risk genetic conditions, a careful survey of the entire abdomen

and pelvis is accompanied by pelvic washings and liberal biopsy of any suspicious lesion. Additionally, the infundibulopelvic ligament should be divided at least 2 cm proximal/cephalad to the ovary at the level of the pelvic brim to ensure all ovarian tissue is removed. Due to the risk of occult carcinoma in these cases, communication with the pathology team is key to ensure enhanced tissue block sectioning is performed.

Intraoperative frozen section diagnosis should be utilized whenever there is significant concern for malignancy. If an unexpected malignancy is encountered, a gynecologic oncology specialist should be consulted intraoperatively to determine if any additional staging biopsies or procedures are required. Even in the event that no gynecologic oncology specialists are immediately available, the general gynecologist should be prepared to perform omental biopsy, Pap smear of the diaphragm, and peritoneal biopsies if indicated by frozen section findings.

# ADNEXAL SURGERY FOR FERTILITY

The past generation of surgeons has witnessed a radical practice shift regarding the role of surgery for the management of the infertile couple. This is the result of increasingly effective techniques of assisted reproduction technology (ART). Even the use of laparoscopy as a diagnostic tool in infertility has, with rare exceptions, become obsolete. This section addresses tubal and ovarian surgery for fertility indications from a modern and practical perspective. We will begin with a realistic assessment of what is currently achievable in terms of ART success in the United States as a comparison to what surgery can currently achieve. We will discuss four topics: (1) the role of tubal surgery (including tubal cannulation, neosalpingostomy, fimbrioplasty, and salpingectomy) for the management of tubal and peritubal obstructive disease, (2) the role of tubal reanastomosis in women who regret sterilization by tubal interruption, (3) the role of laparoscopic ovarian transposition in fertility preservation, and (4) the role of laparoscopic ovarian diathermy in induction of ovulation. We will not specifically discuss

the role of ovarian and tubal surgery in the setting of endometriosis, which is covered in Chapter 40.

The best and most dependable information regarding ART success can be found in the yearly statistics provided by the Society for Assisted Reproductive Technology (SART), available through a link from the Centers for Disease Control and Prevention (CDC) internet site (cdc.gov). The reporting system from SART takes into consideration current practice of ART, including preimplantation genetic screening, single embryo transfer, and subsequent repeated cycles of cryopreserved embryo transfer. SART data are, therefore, reported as final cumulative outcome per egg retrieval cycle. Data from 2019 represent the latest complete statistics available at the time of this publication. They indicate the following age-related final cumulative outcome (live birth) per each egg retrieval cycle: <35 years old = 55.7%, 35-37 years old = 41.5%, 38-40 years old = 27.6%, >40 years old = 9.5. The current SART reporting system, which estimates the cumulative chance of live birth over a follow-up period of 2 years after the intervention, is particularly useful to make meaningful comparisons with the outcomes of surgical treatments. However, in contrast to results reported for SART, surgical outcome results are rarely grouped by patients' ages.

# Surgery for Tubal Obstruction

Some degree of tubal factor is responsible for about one-third of female infertility. Options for addressing tubal factor include ART and tubal surgery. The role of tubal surgery has waned as ART has become safer in recent years with significant technological advances in the field. Most centers report low rates of multiple pregnancies and negligible rates of higher-order multiple pregnancies. Moreover, the iatrogenic complication of ovarian hyperstimulation syndrome has become a rarity in clinical practice.

Given the safe option of ART, tubal surgery is typically reserved for the most stringent indications, as discussed in the sections that follow. Thus, the risk of any surgical complications must be discussed with the patient and her partner in that context. While a thorough evaluation of the infertile couple (age, male factor, and

ovarian function and reserve) is implicit, adequate preoperative imaging is also essential.

The hysterosalpingogram (HSG) remains the single imaging modality that can potentially provide us with all the anatomic information we need for tubal surgery. The HSG can provide an assessment of the status of the endosalpingeal folds, the location and the degree of dilatation of the tube, the presence, rate of flow and amount of a free distal spill, and the presence or absence of loculations of contrast. This information helps to plan a potential surgical intervention and to give our patients a clearer perspective on the practical impact of a tubal surgery. Despite its clear advantages in those cases when the tube can be visualized, the HSG is also a technique with a poor positive predictive factor in the case of proximal tubal blockage. Indeed, when bilateral proximal tubal obstruction is found at HSG, there is a high chance of a false-positive result from tubal spasm, rather than a true physical obstruction. The simplest option in such cases is to repeat the HSG in a subsequent cycle: roughly 60% of such patients will show one or both patent tubes on a repeat HSG.

Persistent bilateral proximal tubal blockage on HSG suggests true anatomical obstruction. This can be due to prior pelvic inflammatory disease, salpingitis isthmica nodosa, or endometriosis and resulting fibrosis. Alternatively, it could be due to the presence of a polyp, myoma, or chronic retained products of conception obstructing the proximal tubal ostium. In these cases, many couples and their doctors will proceed with ART. However, it is important to point out that fallopian tube recanalization can be successfully achieved with catheters, flexible atraumatic guidewires or balloon systems under endoscopic, sonographic, fluoroscopic, or even tactile guidance. While both hysteroscopic and fluoroscopic (interventional radiology) techniques can reestablish proximal tubal patency in nearly 80% of cases, the subsequent ongoing cumulative pregnancy rates are significantly higher with hysteroscopic cannulation (48.9%) vs fluoroscopic techniques (15.6%). While the reason for this discrepancy remains unexplained, it can be argued that a direct visualization technique allows for the least trauma to the tube. Additionally, a surgical approach offers the option to simultaneously

diagnose and treat coincident pelvic pathology at time of hysteroscopy or laparoscopy.

Laparoscopic surgery with chromopertubation and concomitant hysteroscopic tubal cannulation is the most common surgical treatment of proximal tubal obstruction. Following standard diagnostic laparoscopy setup, a classic transcervical chromopertubation is done. If bilateral proximal block is confirmed, the cervical injector/manipulator is removed and a hysteroscope with a 5-French operative channel is placed. A commonly used hysteroscopic tubal catheter is the Novy Cornual Cannulation Set (Cook Medical, Bloomington, IN), which includes a physiologically curved outer catheter with a removable stylet and an inner catheter with a flexible guidewire. The stylet is removed so that the outer catheter curves and can be placed just inside the tubal ostium. The inner catheter and guidewire are then carefully advanced through the intramural segment of the tube and into the proximal isthmus. There is no balloon in this setup: the guidewire itself is intended to resolve the obstruction. Care should be taken to avoid excessive force during this step of the operation in order to minimize the risk for tubal or uterine perforation; the surgeon should have a very low threshold for aborting this procedure in case of resistance while threading the wire. After removing the guidewire, chromopertubation is performed through the inner catheter (**BOX 19.3**). Patients should be warned about the risk of perforation (10%), repeat occlusion (30%), and the possibility of an ectopic pregnancy following successful resolution of the obstruction.

## BOX 19.3 STEPS IN THE PROCEDURE

### Hysteroscopic Tubal Cannulation

- Perform laparoscopy and chromopertubation.
- Treat pelvic pathology by laparoscopy if present.
- Place diagnostic hysteroscope with 5-French channel.
- Place cornual cannulation outer catheter; remove stylet.

- Gently advance inner catheter and guidewire through obstruction.
- Abort procedure if resistance is appreciated.

A failed attempt at hysteroscopic resolution of bilateral proximal tubal obstruction should be addressed with ART. Microsurgical resection of the interstitial tubal segment with isthmic-cornual anastomosis is no longer the preferred approach given the low chance of success, a rate of ectopic pregnancy of up to 29% and the occasional reports of uterine rupture following cornual resection and anastomosis. However, this surgical approach may be considered as an option for reversal of Essure (Bayer, Whippany, NJ) tubal implants. A single center has published their experience with tubocornual anastomosis via minilaparotomy in this specific setting, and a robotic technique for Essure reversal has also been reported.

Despite the diagnostic superiority of falloposcopy in the diagnosis of endoluminal tubal disease, this procedure is technically challenging due to the additional training required for proficiency, and as such is not widely available. In many centers, surgical treatment is generally not the recommended approach for unilateral proximal tubal obstruction; instead ART would be the preferred initial management strategy.

Due to the inherent size discrepancy between the interstitial and the ampullary tubal segments, distal tubal obstruction is not amenable to catheter recanalization techniques. Distal disease is generally caused by an acute or chronic inflammatory process leading to fimbrial conglutination, phimosis, fibrosis, or peritubal adhesion formation enveloping the fimbriae and ampulla. Such inflammation is most often caused by an episode of pelvic inflammatory disease but can also be due to endometriosis, ectopic pregnancy, pelvic surgery, or nonbacterial peritonitis. Surgical approaches to management of distal fallopian tube disease include neosalpingostomy (in the case of complete distal obliteration, **FIG. 19.6**) and fimbrioplasty (**BOX 19.4**, **FIGS. 19.7** and **19.8**).

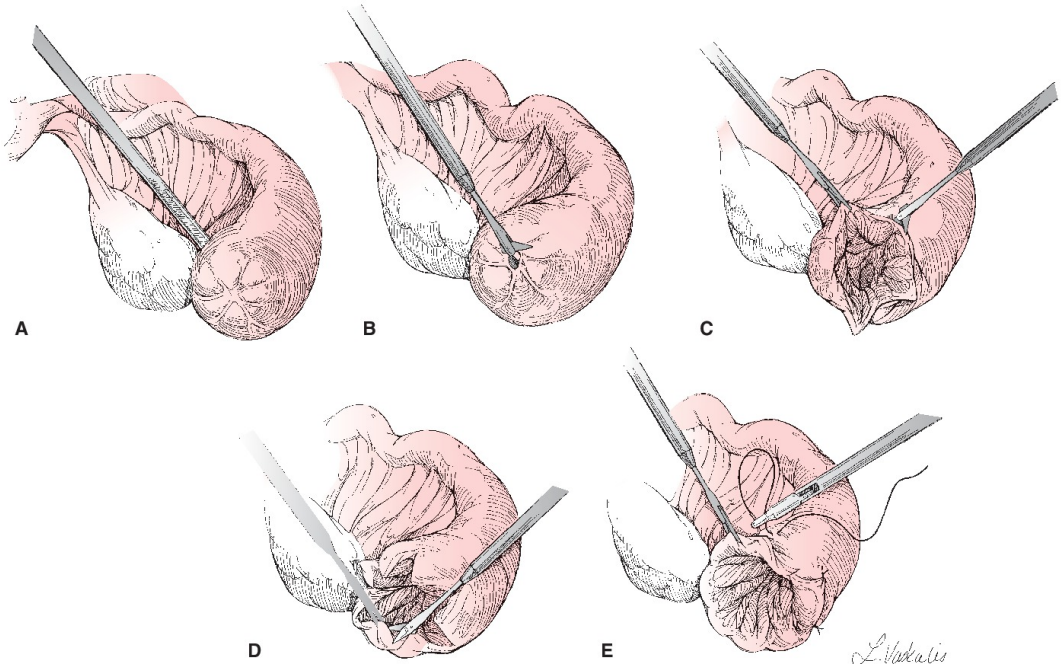



**FIGURE 19.6** Salpingostomy. **A.** The occluded distal end of the tube usually has a centrally placed avascular area, from which avascular scarred lines extend in a cartwheel manner. **B.** The first incision is made along an avascular line toward the ovary. **C.** Avascular lines are incised by viewing from within the tube along the circumference of the initial opening. **D.** Cutting along the avascular lines is continued until a satisfactory stoma is fashioned. **E.** The flaps can be everted by placing two or three no. 6-0 absorbable synthetic sutures. (Reprinted from Gomel V, Taylor PJ. *Diagnostic and Operative Gynecologic Laparoscopy*. Mosby; 1995:174. Copyright © 1995 Elsevier. With permission.)

## BOX 19.4 STEPS IN THE PROCEDURE

### Neosalpingostomy and Fimbrioplasty

- Perform chromopertubation.
- Perform delicate salpingo-ovariolysis if necessary.
- Perform incision(s) at confluence of ampullary adhesions and assess ampullary endosalpinx.
- Proceed with leaflet eversion if endosalpinx is adequate.
- May use cautery or sutures to evert.

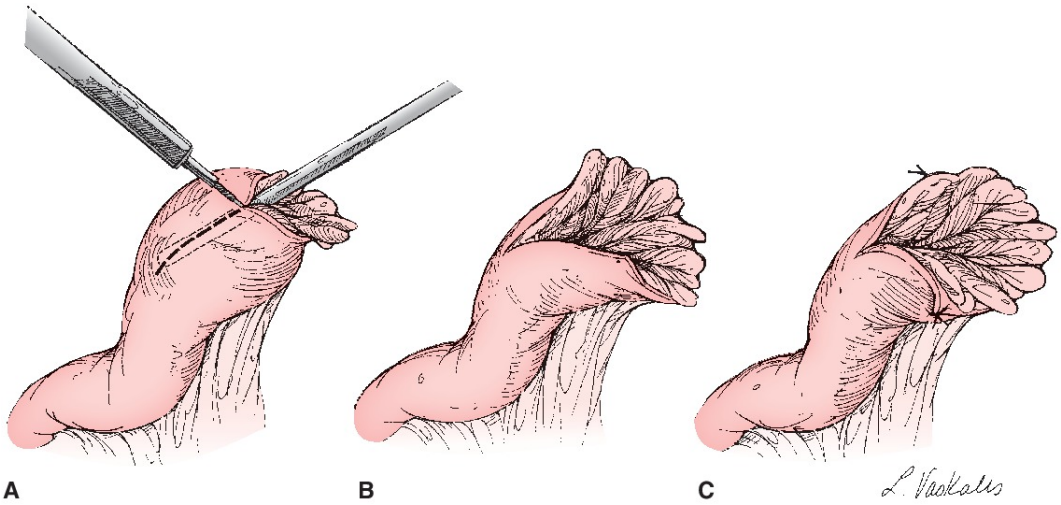



**FIGURE 19.7** Fimbrioplasty: correction of prefimbrial phimosis. **A, B.** An incision is placed at the antimesosalpingeal border of the tube. **C.** Completed procedure with flaps everted. (Reprinted from Gomel V, Taylor PJ. *Diagnostic and Operative Gynecologic Laparoscopy*. Mosby; 1995:173. Copyright © 1995 Elsevier. With permission.)

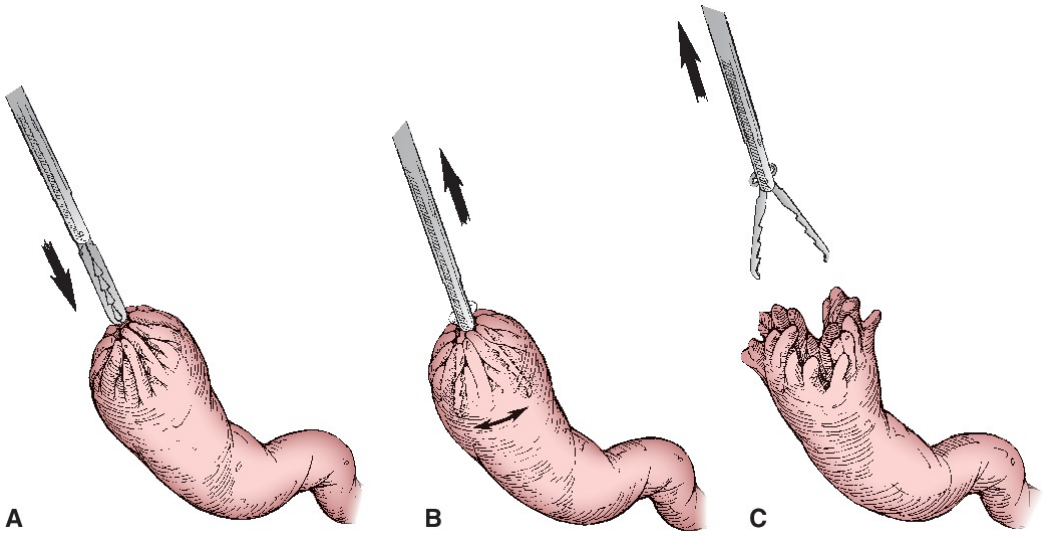



**FIGURE 19.8** Fimbrioplasty: to free agglutinated fimbriae. **A.** The 3-mm alligator-jawed forceps is introduced through the stenosed opening. **B.** The jaws of the forceps are opened within the tube. **C.** The forceps are gently withdrawn while the jaws are kept open. (Reprinted from Gomel V, Taylor PJ. *Diagnostic and Operative Gynecologic Laparoscopy*. Mosby; 1995:173. Copyright © 1995 Elsevier. With permission.)

At the time of this publication, the largest, most recent meta-analysis on the efficacy of neosalpingostomy for distal tubal obstruction encompassed 2810 patients and 22 studies. The meta-analysis found a 27% cumulative spontaneous pregnancy rate. However, the existing literature largely fails to account for important confounding factors such as male factor, female partner's age, anatomical factors (such as tubal damage and adhesion score), surgical technique, and length of follow-up. An additional important caveat is that many of the studies included did not use a classification system for tubal disease, and therefore, these results may suggest a gross

underrepresentation of the potential benefits of neosalpingostomy, particularly in cases with mild tubal disease.

In cases of severe, generalized tubal pathology with hydrosalpinx, one can observe absent endosalpingeal folds on HSG, abnormal or absent tubal epithelium at laparoscopy, and spontaneous accumulation of intraluminal fluid with abnormal tubal distension at ultrasound. In this setting, a fertility-enhancing surgical approach (such as neosalpingostomy or salpingo-ovariolysis) is generally not recommended. In the absence of desired fertility optimization, asymptomatic hydrosalpinges do not require surgery. However, if the patient is experiencing infertility and is planning ART, the presence of hydrosalpinges negatively impacts the rates of pregnancy, implantation, live delivery, and early pregnancy loss. This is felt to result from toxic cytokines effluxing from the dilated tube into the uterus. Thus, surgical treatment should be considered for all women with hydrosalpinges prior to ART. Radical treatment in the form of either laparoscopic salpingectomy or laparoscopic tubal interruption/ligation appears to be equally beneficial to ART success. Therefore, it is important that surgeons limit the extent of tubal excision in cases where peritubal adhesions may make a full salpingectomy a riskier proposition in terms of damage to surrounding reproductive organs. In cases where tubal interruption is performed, fenestration of the occluded tube should be attempted to alleviate the theoretical risk of increasing pain with a tense interrupted hydrosalpinx. Although it is unlikely, torsion after tubal interruption has been reported; however in the case of a hydrosalpinx that is so adherent it cannot be safely excised, torsion is unlikely.

Given the proximity of the mesosalpinx to the underlying mesovarium and ovary, salpingectomy can have a direct impact on ovarian reserve. However, the overall effect of salpingectomy (for ectopic pregnancy or hydrosalpinx) on ovarian reserve is negligible for unilateral and even for bilateral salpingectomy. A large single-center retrospective study also indicated that ART parameters and clinical pregnancy rates do not differ between patients who have undergone laparoscopic salpingectomy and their matched controls.

Ultimately, the impact on ovarian reserve of any given adnexal operation is dependent on surgical technique and execution.

Another strategy to consider in such high-risk surgical patients is the ultrasound-guided aspiration of the hydrosalpinx at the time of transvaginal follicular aspiration for ART. Although simple aspiration is not as effective as salpingectomy or tubal interruption at neutralizing the negative effect of hydrosalpinx on ART success, it may be more effective than no treatment at all. Aspiration of hydrosalpinx followed by injection of a sclerosing agent has been shown to be superior to simple aspiration in avoiding reaccumulation and improving ART success.

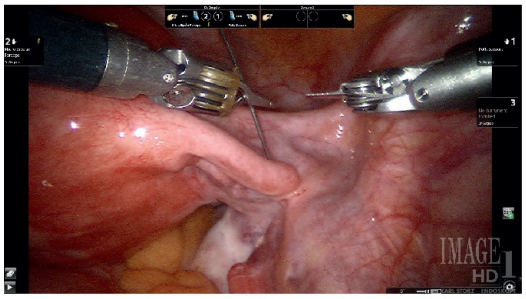
# Tubal Reanastomosis

One in five women who were 30 or younger at the time of sterilization by tubal interruption later regrets their decision. Tubal reanastomosis, in the expert hands of those centers that have published results, can be a highly successful solution. Indeed, it is by far the most rewarding tubal operation, with postprocedure delivery rates that compare very favorably with those afforded by ART. This high success rate may be related to the underlying fertile nature of these patients. Surgeons should offer this technique as an alternative to ART to couples with no other cause of infertility, particularly those for whom multiple gestations or ART is not acceptable.

The classic microsurgical technique for tubal reanastomosis is performed by minilaparotomy: it employs an operative microscope and ultra-fine (usually 7-0 or smaller) sutures to produce an anatomically correct, tension-free anastomosis. As with many gynecologic operations, minimally invasive tubal reanastomosis is a very attractive alternative to open surgery. Before the introduction of surgical robots, a select group of reproductive surgeons were able to faithfully replicate this microsurgical technique with conventional laparoscopy, with excellent results. However, the technical challenges posed by a conventional laparoscopic tubal reanastomosis are formidable, and the American Society for Reproductive Medicine specifically recommends that it should only

be performed by surgeons with extensive training in laparoscopic suturing and conventional tubal microsurgery (VIDEO 19.1).

FIGURE 19.9 depicts the steps of a robot-assisted microsurgical tubal reanastomosis: after preparing the tubal stumps and performing chromopertubation, stents are placed, tubal orientation is confirmed, and a sutured anastomosis is created. The largest published single-center series reports a 54.8% chance of pregnancy and a delivery rate of 72.5% with this technique. Two teams have published their experience with microsurgical tubal reanastomosis, performed laparoscopically with robotic assistance, and have compared their results to the classic open technique. Both show excellent and similar pregnancy rates and ectopic rates, with longer operative times and shorter recovery times. Higher direct procedure costs for the robotic technique are a concern for centers in which both robotic and open procedures are offered in a day surgery setting. The largest outcome study on robotic tubal reanastomosis is a retrospective cohort of 97 women aged 24-47 years (median age 37 years) with proven normal ovarian reserve and normal male partners' semen analyses; these data are the best currently available to counsel patients based on their age-dependent chance for success. The overall pregnancy and live birth rates at 2 years after surgery were 71% and 62%, respectively. These authors report the following age-related final cumulative outcome (live birth): 35 years old and under = 88%, 36-39 years old = 66%, 40-42 years old = 43.8%, and 43 years old and above = 8%. A study on cost comparison highlights the negative effect of advancing reproductive age, demonstrating that tubal anastomosis was the most cost-effective approach for women <41 years of age, but ART was more cost-effective for women aged ≥41 years (BOX 19.5).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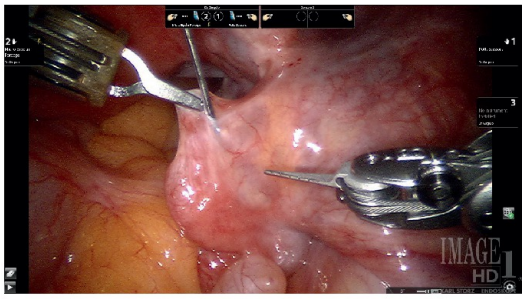
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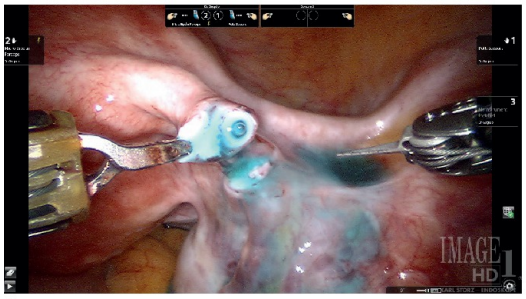
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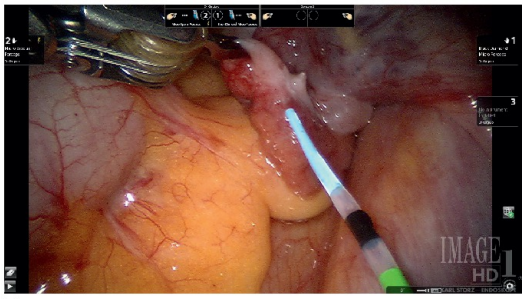
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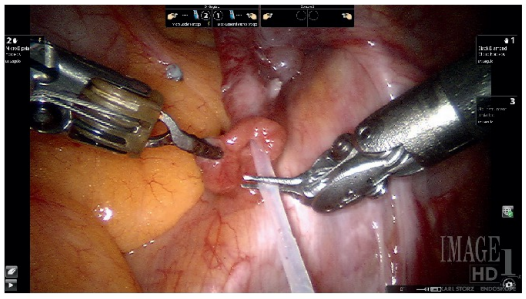
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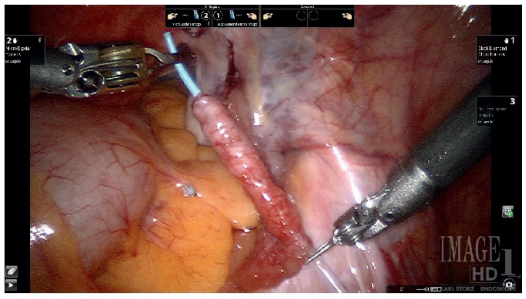
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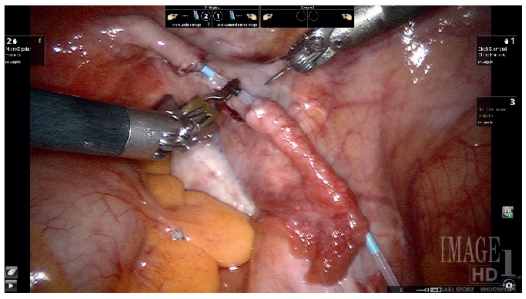
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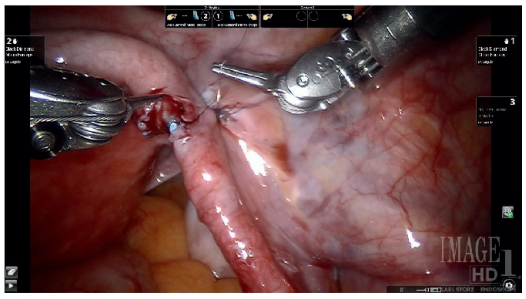
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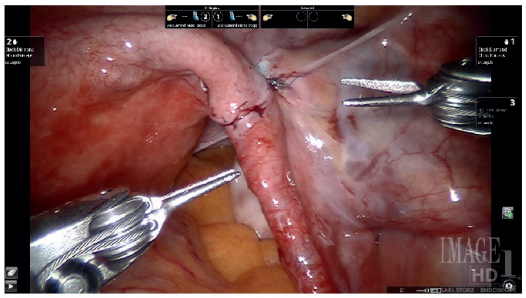
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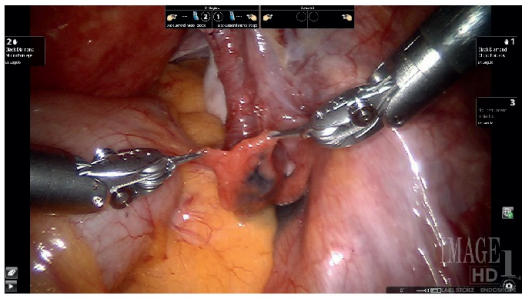
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**FIGURE 19.9** Robot-assisted microsurgical tubal reanastomosis. **A.** Diluted vasopressin is injected in the mesosalpinx at the proximal stump of the interrupted tube. **B.** Diluted vasopressin is injected in the mesosalpinx at the distal stump of the interrupted tube. **C.** The proximal tubal stump is freed of adhesions, and the tubal lumen is demonstrated to be patient with chromopertubation. **D.** A stent is introduced in the distal tubal ostium. **E.** The stent is pushed through the tubal ampulla. **F.** The distal tubal stump is prepared for reanastomosis with the stent in place. **G.** The stent is introduced in the lumen at the proximal tubal stump. **H.** The defect in the mesosalpinx is closed with a 6-0 Vicryl figure-of-8 stitch. This fundamental step accomplishes a dual purpose: (1) creates tension-free anastomosis conditions and (2) establishes the perfect orientation of the tubal segments about the stent. **I.** With the stent in place, three 8-0 Prolene sutures are placed through the tubal serosa and muscularis, skimming the lumen. This completes the anastomosis. **J.** Chromopertubation is repeated after removal of the stent, showing

fill of the distal segment and free spill. (Courtesy of Dr. Antonio Gargiulo.)

## BOX 19.5 STEPS IN THE PROCEDURE

### Tubal Reanastomosis

- Perform minilaparotomy or laparoscopy (conventional/robotic).
- Prepare tubal stumps and perform chromopertubation.
- Place stent and define correct orientation.
- Decrease tension on anastomosis line by repairing mesosalpinx gap.
- Choose multiple point anastomosis to avoid misalignment.
- Use 7-0 or smaller suture (absorbable or permanent).

# Ovarian Transposition

Ovarian transposition is a simple, safe, effective, and underutilized fertility-sparing procedure for women who are planning to undergo cancer treatment by radiotherapy. Women who will receive pelvic radiation for lymphoma, cervical, anal, rectal, or urinary tract cancers may benefit from ovarian transposition. The procedure relocates the ovaries, while preserving their original vascular bundle, to spare them from sterilizing doses of radiation (**FIG. 19.10**). In case of craniospinal irradiation, the ovaries can be fixed laterally, as far as possible from the spine. In case of pelvic irradiation, the ovaries are moved outside of the pelvis, by transecting the utero-ovarian ligament (and in some cases, the proximal fallopian tube) and securing the ovary as high as possible in the paracolic gutter (**FIG. 19.11**).

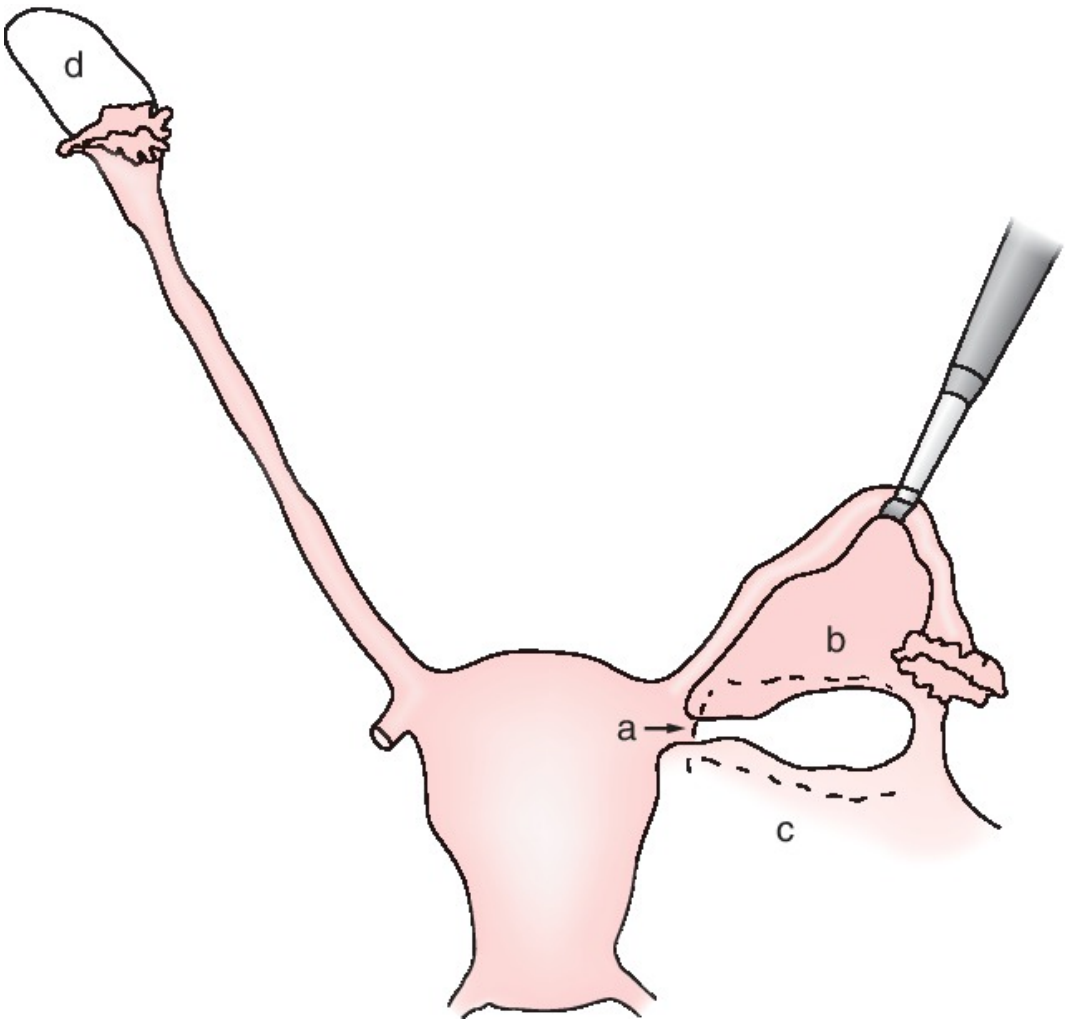


**FIGURE 19.10** Laparoscopic ovarian transposition. Ovarian ligament (*a*) and mesovarium (*b*) are divided. If mobility is inadequate, relaxing incision on peritoneum inferior to ovary (*c*) may be needed. Final location of ovary is shown (*d*). (Redrawn from Bisharah M, Tulandi T. Laparoscopic preservation of ovarian function: an underused procedure. *Am J Obstet Gynecol*. 2003;188(2):367-370.)

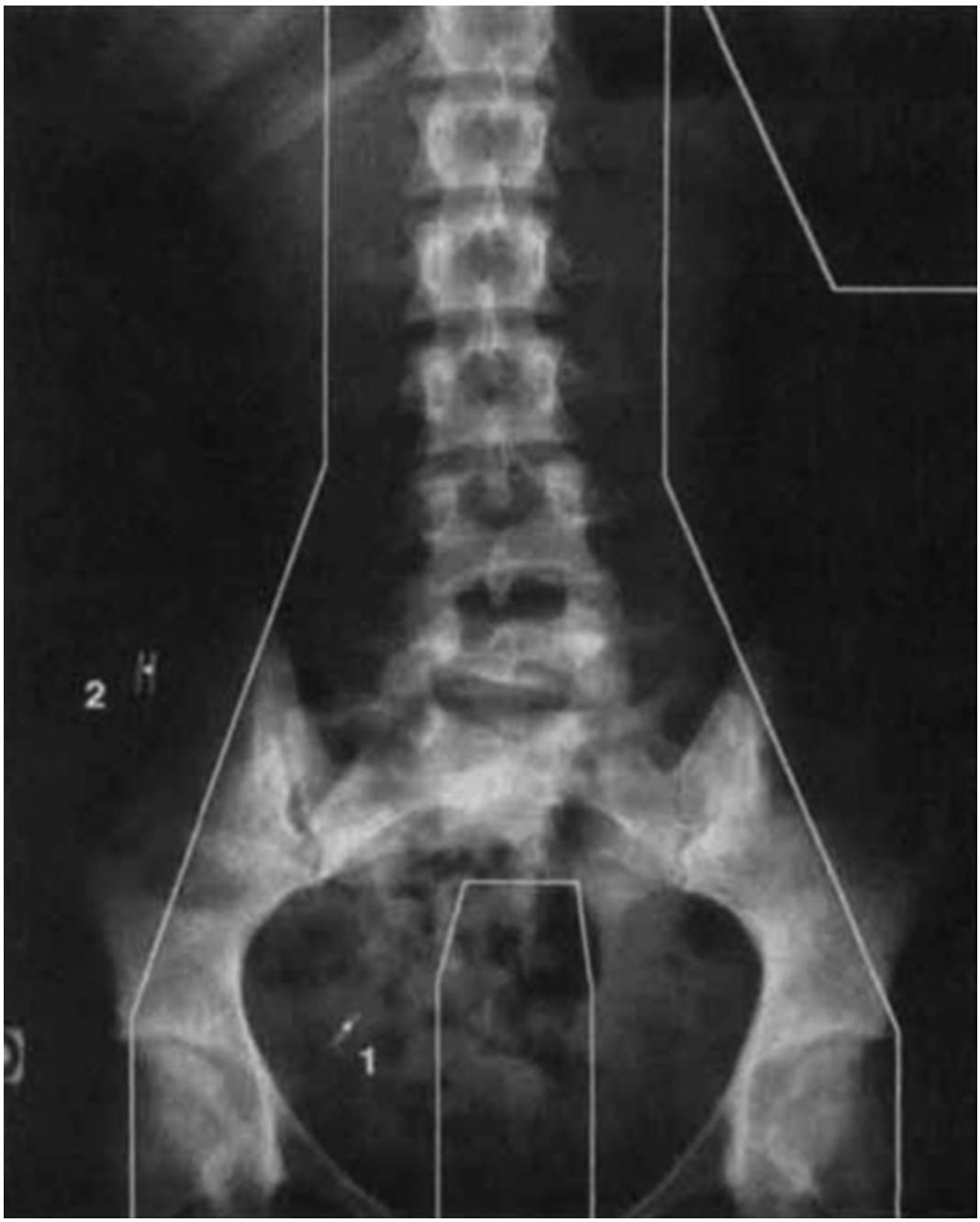


**FIGURE 19.11** Laparoscopic transposition of the right ovary before inverted Y radiotherapy for Hodgkin disease. The irradiation field is outlined with a *white line*. Two metal clips have been applied on the transposed ovary (*2*), whereas one clip marks the original

position of the ovary before transposition (*1*). (From Clough KB, Goffinet F, Labib A, et al. Laparoscopic unilateral ovarian transposition prior to irradiation: prospective study of 20 cases. *Cancer*. 1996;77(12):2638-2645. Copyright © 1996 American Cancer Society. Reprinted by permission of John Wiley & Sons, Inc.)

Ovarian transposition was performed by laparotomy before the advent of minimally invasive surgery; several safe and effective laparoscopic techniques have now been described and are typically preferred. A minimally invasive approach increases patient acceptability and facilitates a timelier transition to radiation therapy. As for any laparoscopic surgery that involves delicate dissection and intracorporeal suturing, robot-assisted laparoscopy can be considered. Robot-assisted laparoscopic ovarian transposition was described in 2003, and more recently, a larger case series has confirmed its safety and feasibility. A robot-assisted laparoscopic approach may prove advantageous when the need for retroperitoneal dissection or extensive adhesiolysis is encountered. The original technique placed the patient-side robotic cart at the head of the table and introduced the robotic laparoscope through a suprapubic trocar in order to facilitate visualization of both the adnexa and the upper pelvis to avoid having to dock for pelvic work and then again for upper abdomen work. This is no longer necessary with new-generation, cantilever robotic platforms, where standard robotic port placement allows pelvic dissection in the usual orientation, followed by arm rotations at the tip of the boom to work in the upper abdomen, without the need to reposition the robot.

According to a recent meta-analysis, ovarian transposition is associated with significant preservation of ovarian function and negligible risk of metastases to the transposed ovaries, despite the common incidence of ovarian cysts. If the proximal tubes are

transected or nonfunctional following transposition, oocyte retrieval for ART can be effectively performed transabdominally without the need to reposition the ovaries.

## Ovarian Diathermy

It may seem counterintuitive that thermal destruction of ovarian tissue would be performed with the goal to reestablish spontaneous ovulation and assist women in getting pregnant. However, laparoscopic ovarian diathermy (LOD) by laser or electrocautery (**FIG. 19.12**) is an accepted therapeutic option for infertile women with polycystic ovary syndrome (PCOS) who have failed to respond to medical ovulation induction. This technique is conceptually related to ovarian wedge resection, which is currently of historical interest only. They share the same controversial justification: by eliminating some of the androgen-synthesizing tissue from the ovarian medulla, the cortical tissue may respond more adequately to pituitary gonadotropins. However, even if performed by a minimally invasive approach, any technique that aims to destroy a portion of ovarian tissue is inherently traumatic to the gonads (and possibly traumatic to the surrounding tissues as well). Therefore, these operations carry the potential for complications including adhesion formation and decreased ovarian reserve. In a world where ART has become increasingly safe and more widely available, the cost, pain, and risks associated with ovarian surgery for ovulation induction make it a less attractive option that would typically be considered after every alternative option has been explored.

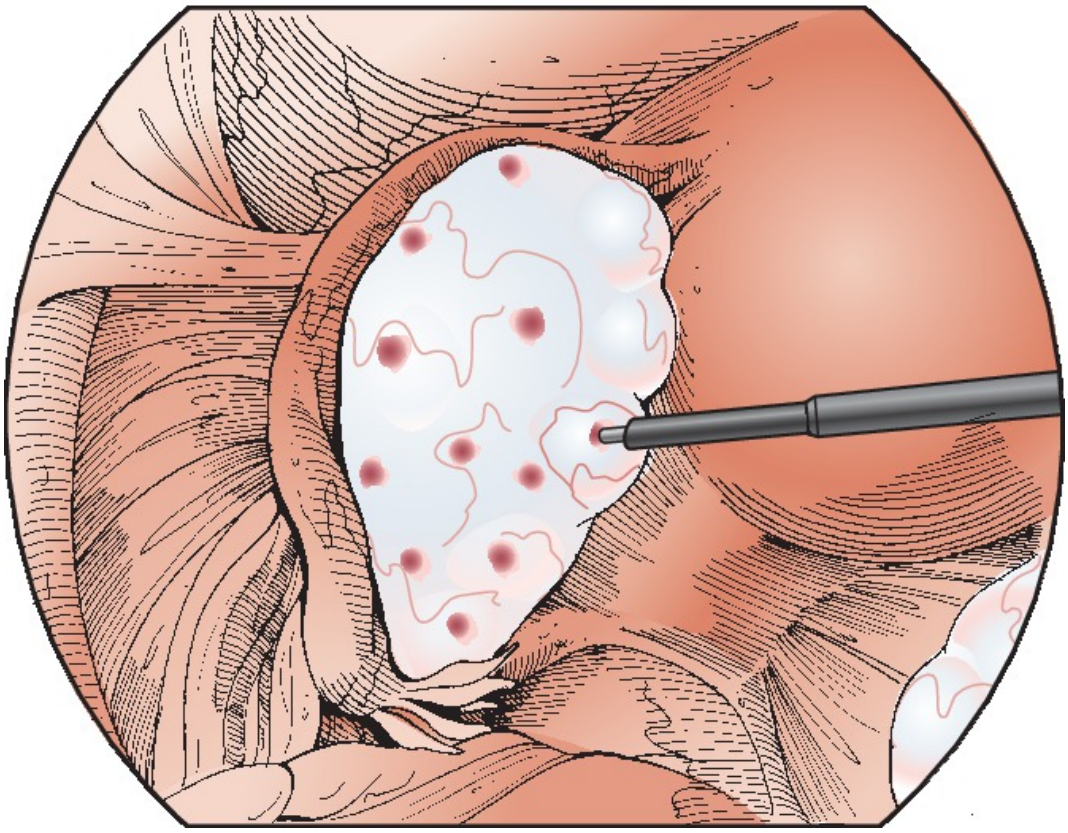

**FIGURE 19.12** Laparoscopic ovarian diathermy. (Reprinted with permission from Cundiff GW, Azziz R, Bristow RE. *Te Linde's Atlas of Gynecologic Surgery*. 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2014. Figure 25.5.)

This treatment is only indicated for women with PCOS resistant to ovulation induction with oral agents. In these cases, if ART is not available, not affordable, or not otherwise acceptable to the couple, LOD can be employed as an alternative to ovulation induction with gonadotropins. The pregnancy rate after LOD is similar to that obtained with the use of injectable gonadotropins. The main argument for LOD is the lower rate of multiple pregnancies vs gonadotropin ovulation induction. However, patients need to be

informed about ongoing concerns regarding the long-term effects of LOD on ovarian function and reserve. Unilateral vs bilateral ovarian diathermy should also be discussed, as a recent meta-analysis has demonstrated similar results and improved antral follicle counts in patients randomized to unilateral LOD. Additionally, patients should be informed that the impact of LOD on subsequent ART cycle success is controversial: some show no effect, while others show a significant worsening of all parameters.

# KEY POINTS

- In the majority of cases, a minimally invasive approach to adnexal surgery is preferred due to decreased perioperative morbidity and recovery advantages.
- The primary contraindication to ovarian cystectomy for an ovarian mass is in cases where there is a significant suspicion of malignancy.
- At time of ovarian cystectomy, care should be taken to remove the entire cyst wall to prevent cyst reformation and achieve meticulous hemostasis without destruction of normal ovarian tissue.
- At time of oophorectomy, retroperitoneal dissection may be needed to identify the ureter and isolate the gonadal vasculature.
- Given the safety of ART, surgery for correction of tubal factor infertility should be reserved for limited indications.
- Proximal tubal occlusion is best treated by laparoscopic surgery with chromopertubation and concomitant hysteroscopic tubal cannulation.
- Hydrosalpinges should be removed or interrupted prior to ART.
- Tubal reanastomosis is an effective alternative to ART in the setting of tubal sterilization regret.

- Ovarian transposition is an excellent option to preserve ovarian function in patients undergoing cancer treatment by radiotherapy.
- Laparoscopic ovarian diathermy is a second-line option in the management of patients with infertility associated with PCOS who have failed oral ovulation induction agents.

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# CHAPTER 20

# SURGICAL MANAGEMENT OF ECTOPIC PREGNANCY

Katharine O'Connell White and Paula M. Castaño

**Epidemiology**
Risk Factors
**Diagnosis**
Presentation
Ultrasonography
Serum hCG Testing
Diagnostic Aspiration
Diagnostic Laparoscopy
**Tubal Pregnancy**
**Cesarean Scar Pregnancy**
**Interstitial Pregnancy**
**Ovarian Pregnancy**
**Cervical Pregnancy**
**Abdominal Pregnancy**
**Rudimentary Horn Pregnancy**
**Heterotopic Pregnancy**
**Postoperative Care**

# EPIDEMIOLOGY

Ectopic pregnancy is the implantation of a fertilized ovum outside the endometrial cavity. This implantation may occur anywhere along the reproductive tract, most commonly the ampullary portion of the fallopian tube **(FIG. 20.1)**.

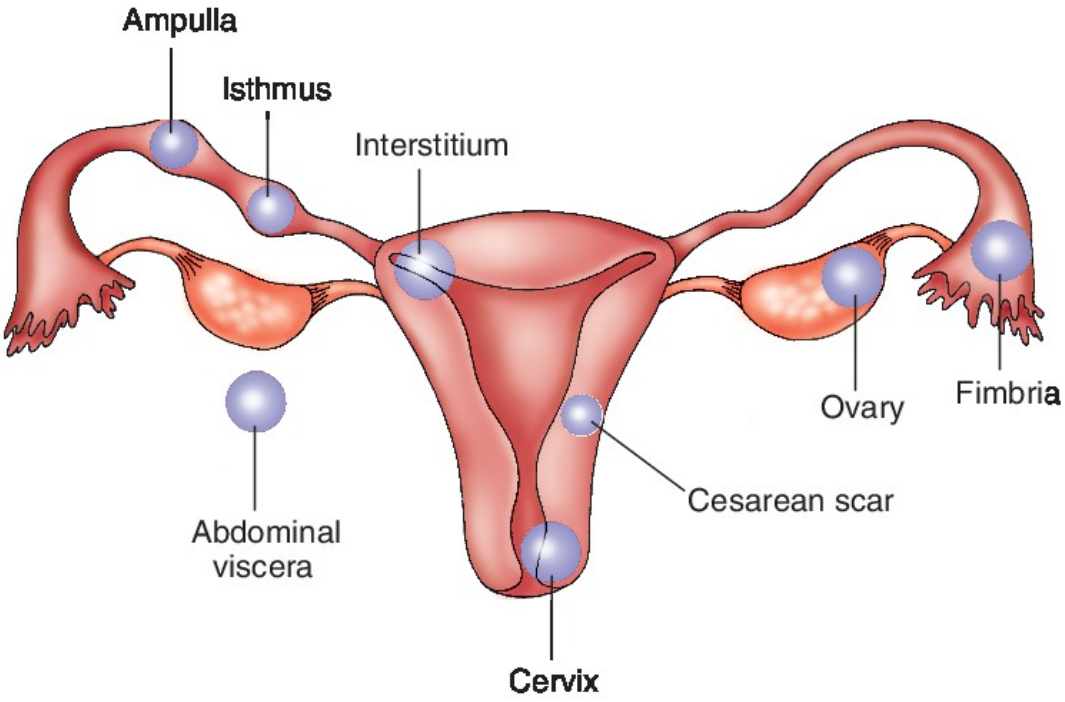



**FIGURE 20.1** Sites of ectopic pregnancy. In the vast majority of patients with ectopic pregnancy, the ovum implants in part of the fallopian tube: the fimbria, ampulla, or isthmus. (Modified from Willis LM. *Health Assessment Made Incredibly Visual*. 3rd ed. Wolters Kluwer, 2016.)

Rates of ectopic pregnancy vary depending on which numerator (diagnosed ectopic pregnancies or those that are diagnosed and

treated) and denominator (all pregnancies or only deliveries) are used. Analyses from a large commercial claims database and the Medicaid claims database from 2002 to 2013 showed a relatively low and stable rate of ectopic pregnancy for women of reproductive age in the United States (1.0%-1.4% as a proportion of all deliveries).

Despite advances in diagnosis and management, ruptured ectopic pregnancy continues to be a significant source of pregnancy-related morbidity and mortality and represents 2.7% of pregnancy-related deaths. Mortality and morbidity continue to be higher among women from racial and ethnic minority groups (compared with white women) and among women of lower socioeconomic status (who already have a higher baseline risk of pregnancy complications). These disparities may be partly related to differential use of medical vs surgical management by race and insurance status and more broadly related to differences in access to care.

Increasing access to early pregnancy care is key, as early diagnosis of ectopic pregnancy leads to timelier treatment, reducing morbidity and preserving future fertility. Increasing restrictions on pregnancy termination may inadvertently and unnecessarily lead to delay in diagnosis, further complicating treatment of ectopic pregnancy.

# Risk Factors

The risk of recurrence of ectopic pregnancy is ~10% after one ectopic pregnancy and rises to at least 25% after two or more previous ectopic pregnancies. Thus, prior ectopic pregnancy is strongly associated with recurrence. Other primary risk factors for ectopic pregnancy include damage to the fallopian tubes from pelvic inflammatory disease and previous abdominopelvic surgery. Secondary risk factors include tobacco smoking and consuming ≥10 g/d of alcohol; more recent data call into question the significance of increasing age and multiple lifetime sexual partners as independent risk factors. Prior obstetrical outcomes of miscarriage and therapeutic abortion do not confer an increased risk of ectopic pregnancy. Use of an intrauterine device (IUD) is overall protective against ectopic pregnancy, as the method failure rate is <1%.

However, of pregnancies resulting from IUD failure, as many as 53% are ectopic. Ectopic pregnancies in IUD users are more likely to be distal tubal ectopic pregnancies, ovarian ectopics, or abdominal pregnancies. It is hypothesized that while the IUD prevents intrauterine implantation, it does not protect against more distal implantation. The use of assisted reproductive technologies, particularly *in vitro* fertilization, increases the risk of ectopic pregnancy. And women with a history of infertility are at an increased risk of ectopic pregnancy independent of how they became pregnant. It is important to remember that half of women who experience an ectopic pregnancy possess no known risk factors, so the diagnosis must be considered for all reproductive-aged patients who present with symptoms.

# DIAGNOSIS

## Presentation

Patients with an ectopic pregnancy may be asymptomatic or may present with vaginal spotting or pelvic pain. These symptoms are nonspecific; they can occur with a viable intrauterine pregnancy or a spontaneous abortion as well, and therefore, symptoms alone cannot distinguish between a normal and an abnormal pregnancy. Vaginal bleeding in patients with ectopic pregnancy is due to the sloughing of the decidual endometrium and can range from spotting to menseslike flow. The passage of a decidual cast may mimic the passage of pregnancy tissue. Therefore, a history of vaginal bleeding and passage of tissue cannot alone differentiate ectopic pregnancy from early intrauterine pregnancy failure.

Cramping pain with ectopic pregnancy may begin as colicky abdominal or pelvic pain that may be diffuse or lateralize to the side of the abnormal pregnancy. Other potential symptoms include presyncope, syncope, vomiting, diarrhea, shoulder pain, lower urinary tract symptoms, rectal pressure, or pain with defecation. Patients with these symptoms should be considered at risk for ectopic pregnancy until the pregnancy is localized. This moment in care is an opportunity to assess the patient's desire for pregnancy, a

factor which will guide management decisions (**FIG. 20.2**). At the other end of the spectrum, patients with a ruptured ectopic pregnancy may present with severe abdominal pain, rebound tenderness, and signs of shock, including hypotension and tachycardia, and require emergency surgery. Screening of asymptomatic people for ectopic pregnancy has not been shown to be cost-effective.

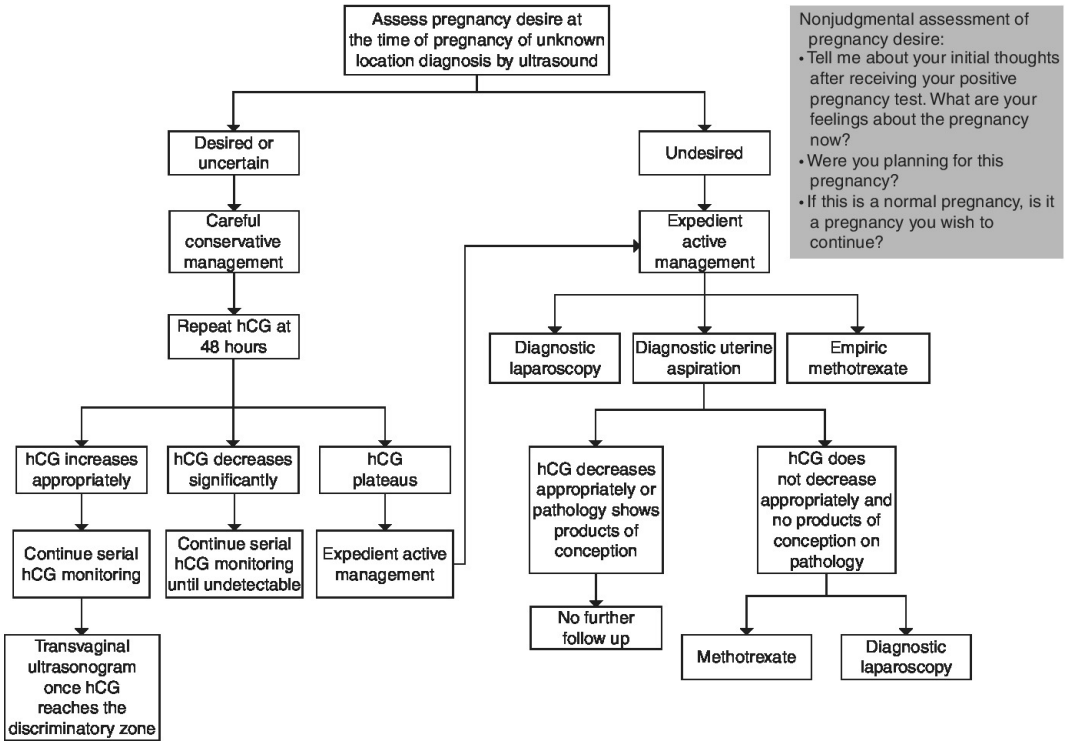



**FIGURE 20.2** Algorithm for management of pregnancy of unknown location. (Adapted with permission from Flynn AN, Schreiber CA, Roe A, et al. Prioritizing desiredness in pregnancy of unknown location: an algorithm for patient-centered care. *Obstet Gynecol*. 2020;136:1001-1005. Copyright © 2020 by The American College of Obstetricians and Gynecologists.)

# Ultrasonography

Ultrasound is a valuable tool in the evaluation of suspected ectopic pregnancy, although an experienced sonographer is needed for careful examination of the adnexa. An intrauterine pregnancy (IUP) should be visible by 5 weeks of gestation. The gestational sac will appear first, followed by a yolk sac at 5.5 weeks, and then an embryo at 6 weeks. If the pregnancy appears to be in the uterus, confirmation is required that the sac is not in the uterine cornua, over a prior cesarean scar, or in the cervix. Transvaginal ultrasonography (TVUS) provides better resolution of the uterus and adnexa than transabdominal imaging. The sensitivity of TVUS for the diagnosis of ectopic pregnancy ranges from 73% to 93%, although the sensitivity is dependent on both the gestational age and the expertise of the ultrasonographer.

There are four potential outcomes of an ultrasound in early gestation:

1. *Viable intrauterine pregnancy*, presence of an embryo with cardiac activity.
2. *Ectopic gestation*, which may appear as a noncystic mass, a hyperechoic ring (bagel sign), or less frequently, a clear extrauterine gestational sac with or without a fetal pole, and with or without fetal cardiac activity (**FIG. 20.3**).
3. *Abnormal intrauterine pregnancy*, where an intrauterine pregnancy is confirmed (by the presence of a gestational sac with a yolk sac), but the pregnancy appears abnormal—for example, a large gestational sac without an embryo or an embryo >7 weeks with no cardiac activity.
4. *Nondiagnostic, or pregnancy of unknown location*, including inconclusive findings in the uterine cavity or in the adnexa. A “pseudogestational sac,” due to a decidual cast, can be present in the uterine cavity and can be mistaken for an amniotic sac; in the absence of a yolk sac, such structure cannot be taken as diagnostic of an intrauterine pregnancy. Approximately 25%-50% of people with an ectopic pregnancy initially present with a pregnancy of unknown location, which is not a diagnosis

but a temporary state, prior to final determination of the location of the pregnancy.

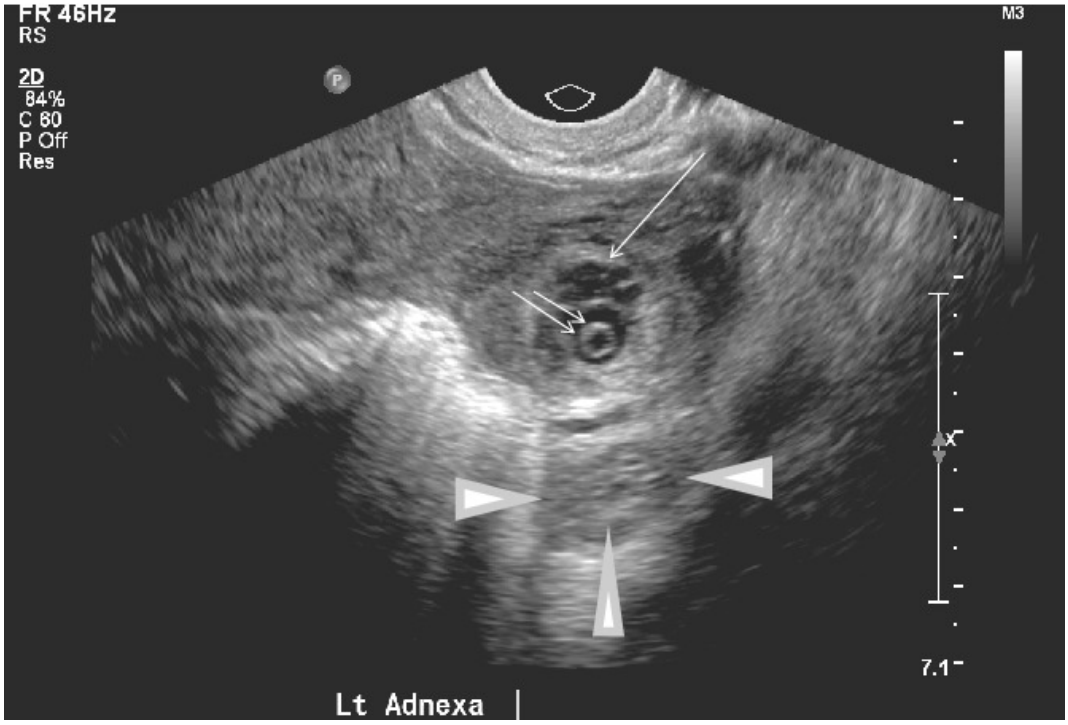



**FIGURE 20.3** Tubal ectopic pregnancy documented by transvaginal ultrasonography. TVUS transverse image through the left adnexa showing a tubal ectopic pregnancy with an extrauterine complex cystic mass containing the gestational sac (*arrow*) and yolk sac (*double arrow*) in the left adnexa adjacent to the left ovary (*arrowheads*). Note that the echogenic rim of the tubal ectopic is more echogenic than the adjacent ovarian parenchyma. (Reprinted with permission from Pope TL, Harris JH. *Harris & Harris' the Radiology of Emergency Medicine*. 5th ed.

Wolters Kluwer Health/Lippincott Williams & Wilkins; 2013. Figure 16.23B.)

## Serum hCG Testing

If pregnancy location cannot be visualized on ultrasound, the level of serum beta human chorionic gonadotropin (hCG) will suggest how far the pregnancy has progressed. The sonographic findings of a normally developing intrauterine pregnancy should be visible by transvaginal ultrasound at an hCG around 1500 to 2500 mIU/mL, the so-called "discriminatory zone." This range will vary with the type of ultrasound machine used, the expertise of the sonographer, the number of gestations, and the institutional hCG assay. Consequently, each institution must determine their own discriminatory thresholds for the ultrasound detection of an intrauterine pregnancy.

When the initial hCG level is *below* the discriminatory zone, repeat hCG testing in 48 hours is indicated. Serum hCG levels increase in a log-linear fashion in early pregnancy, until they reach a plateau of ~100 000 mIU/mL by 10 weeks of gestation. The expected increase in value is dependent on the initial level; hCG levels will increase more slowly when the initial value is high (**TABLE 20.1**). Nonviable pregnancies—which may be intrauterine or ectopic—will have rates of increase slower than these estimates. However, expected rates of hCG rise do not exclude an ectopic gestation; about 50% of women with an ectopic pregnancy present with increasing hCG levels and 50% present with decreasing hCG values.

### TABLE 20.1
### Expected Rate of Increase of hCG Level in Early Pregnancy

| INITIAL HCG LEVEL (mIU/mL) | 1 DAY LATER | 2 DAYS LATER | 7 DAYS LATER |
|---|---|---|---|
| 100 | 1.37 | 1.84 | 6.43 |
| 500 | 1.29 | 1.64 | 4.28 |
| 1000 | 1.25 | 1.55 | 3.53 |
| 1500 | 1.23 | 1.49 | 3.12 |
| 2000 | 1.22 | 1.46 | 2.86 |
| 2500 | 1.20 | 1.43 | 2.66 |
| 3000 | 1.19 | 1.40 | 2.50 |
| 3500 | 1.18 | 1.38 | 2.38 |
| 4000 | 1.18 | 1.36 | 2.27 |
| 4500 | 1.17 | 1.35 | 2.17 |
| 5000 | 1.16 | 1.33 | 2.09 |

Data represent the predicted increase (multiples of initial value) at the first percentile for people with ongoing intrauterine pregnancies.
hCG, human chorionic gonadotropin.
Reprinted with permission from Barnhart KT, Guo W, Cary MS, et al. Differences in serum human chorionic gonadotropin rise in early pregnancy by race and value at presentation. *Obstet Gynecol*. 2016;128(3):504-511. Copyright © 2016 by The American College of Obstetricians and Gynecologists.

Repeat hCG testing in 48 hours will lead to one of three results (**FIG. 20.2**):

1. *Expected rise*. If the hCG level is rising as expected, an ultrasound can be repeated when the levels exceed the discriminatory threshold.

2. *Expected fall*. Abnormal intrauterine pregnancies should have declining hCG levels of ~21%-35% in 2 days depending on initial levels. As the risk of ectopic pregnancy rupture persists even with low or decreasing hCG levels, patients should be monitored until hCG is undetectable.
3. *Abnormal rise or fall*. When hCG levels are increasing or decreasing at a slower rate than expected, an abnormal pregnancy can be confirmed. An increase or decrease of <10%-15% can be considered a stagnant value and should be treated as an abnormal rise or fall.

When the initial hCG level is *above* the discriminatory zone, the absence on ultrasound of an intrauterine pregnancy strongly suggests either an abnormal or ectopic gestation. It is important to consider that people with multiple gestations may have hCG levels well above 2000 mIU/mL before a gestational sac is visualized. Although the combination of an absence of sonographic evidence of intrauterine pregnancy with an initial hCG level between 2000 and 3500 mIU/mL is strongly suggestive of an abnormal pregnancy, a patient with this presentation and a desired pregnancy should have a repeat hCG in 48 hours, to prevent interruption of a desired normal pregnancy.

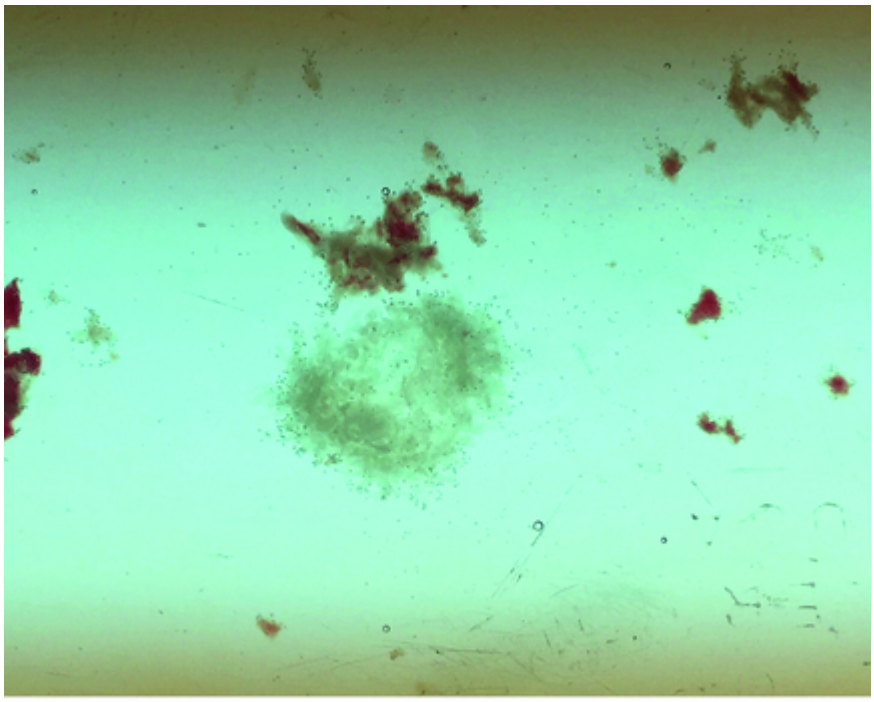
Serum progesterone level is of limited utility, as it is not able to reliably discriminate between a spontaneous abortion and an ectopic pregnancy, though a level below 5 ng/mL is diagnostic of an abnormal pregnancy.

# Diagnostic Aspiration

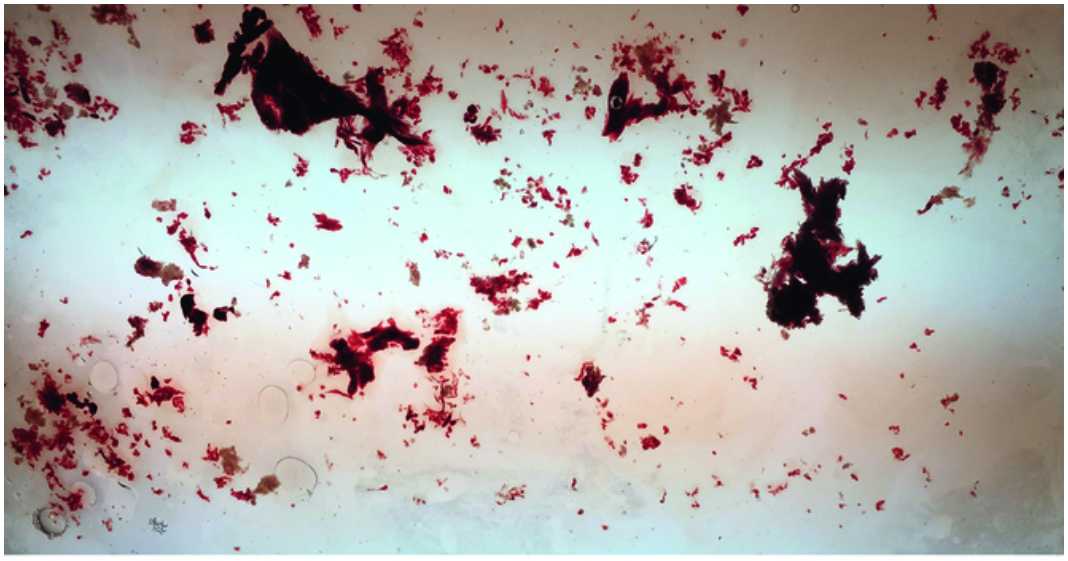
An abnormal pregnancy can, therefore, be diagnosed by either a high initial hCG (above 3500 mIU/mL) and no pregnancy visible on ultrasound or abnormal serial hCG testing (inappropriately rising, falling, or stagnant values). In the latter case, the hCG values may never reach the discriminatory threshold, but a viable intrauterine pregnancy can be reasonably ruled out. To distinguish between early pregnancy failure and an ectopic pregnancy, a vacuum aspiration can be performed. This diagnostic procedure can be performed by

manual or electric aspiration and can be completed in an emergency room, outpatient setting, or operating room, depending on institutional practice. The other indication for a diagnostic aspiration in a pregnancy of unknown location is when the pregnancy is undesired, and there is no need to establish viability before pregnancy termination.

Gross tissue inspection may reveal a gestational sac or chorionic villi, even if not visualized on ultrasound (**FIG. 20.4**). The presence of a sac or villi confirms an intrauterine gestation. If a gestational sac or villi are not grossly evident, follow-up with a rush pathology exam is recommended.



**A**



B

**FIGURE 20.4** Diagnostic aspiration. **A.** Uterine aspirate showing chorionic villi and a small gestational sac. **B.** Decidual tissue with no chorionic villi seen. (Images courtesy of Dr. Katharine White.)

If chorionic villi are not confirmed by either gross or microscopic assessment of the contents of the uterine aspirate, further testing is required, as pathologic assessment for villi can be falsely negative in a very early pregnancy. In this case, a serum hCG can be obtained; when trophoblastic cells are removed from the uterus, whether confirmed by inspection or not, the hCG level will likely decrease by at least 15% in the 12-24 hours after aspiration. In the absence of confirmatory villi, declining hCG levels should continue to be monitored until levels are undetectable. While incomplete evacuation is possible, ectopic pregnancy is highly likely if the hCG levels plateau or increase during this time.

It is critical to not continue to monitor hCG levels once an abnormal trend has been identified. When serial hCG levels are not rising at the minimally expected rate in **TABLE 20.1**, the pregnancy is most likely (in 99% of cases) either a spontaneous abortion or an

ectopic gestation. Further serum hCG levels are not likely to contribute to the diagnosis and may delay recognition of an ectopic pregnancy.

## Diagnostic Laparoscopy

Diagnostic laparoscopy may be indicated for patients who do not want to wait for the results of further serum testing, especially if an adnexal mass is suspected, or for patients who are likely to be noncompliant with follow-up. Additionally, surgery is the optimal management in the setting of peritoneal signs or significant blood in the cul-de-sac or near the liver on ultrasound. If no ectopic pregnancy is visualized on ultrasound, patients undergoing laparoscopy should be counseled that surgery may not provide definitive treatment (if the pregnancy itself cannot be visualized and subsequently removed). If a clear diagnosis is not established by laparoscopy, ongoing close follow-up is warranted.

# TUBAL PREGNANCY

Ectopic pregnancies are most commonly located in the fallopian tube. They are increasingly managed with methotrexate (MTX). The use of MTX rose from 15% of cases in 2006 to 27% of cases in 2015, with a concurrent decline in surgical management. Intramuscular MTX can be considered in patients who are hemodynamically stable, have no absolute contraindications, and are willing to comply with ongoing surveillance until complete pregnancy resolution. Absolute contraindications to medical therapy include lactation, immunodeficiency, hepatic disease, hematologic abnormalities, interstitial lung disease, MTX sensitivity, peptic ulcer disease, and renal dysfunction. Medical management may be preferable in patients with contraindications to surgery such as severe pelvic adhesive disease and medical comorbidities.

Surgical management is mandated when patients exhibit signs of hemodynamic instability. Surgeons have two decisions to make when determining the optimal surgical approach to a tubal pregnancy: type of entry (laparoscopy vs laparotomy) and specific

procedure (“conservative” tubal-sparing salpingostomy, **FIG. 20.5**, vs the more “radical” salpingectomy, **FIG. 20.6**).

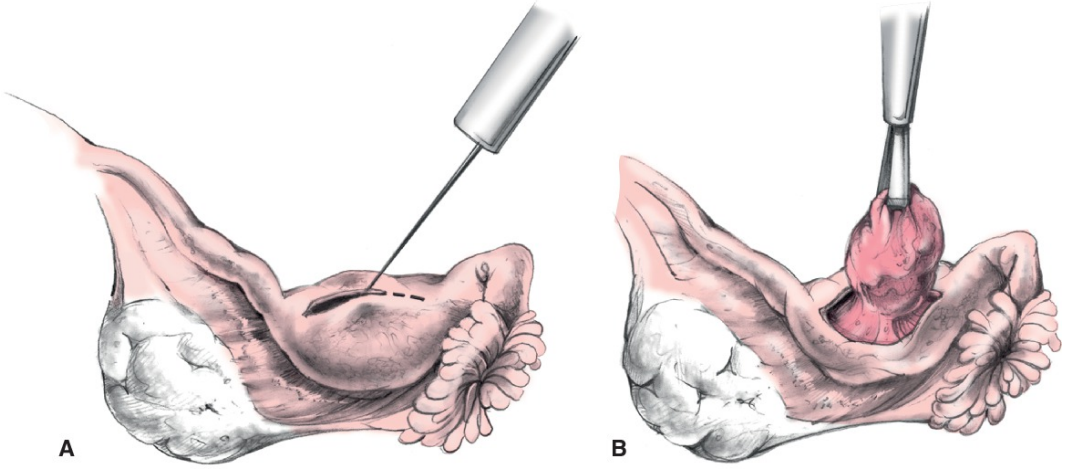



**FIGURE 20.5** Laparoscopic salpingostomy for ectopic pregnancy. **A.** An incision is made along the antimesenteric border of the oviduct. **B.** The trophoblastic mass is removed.

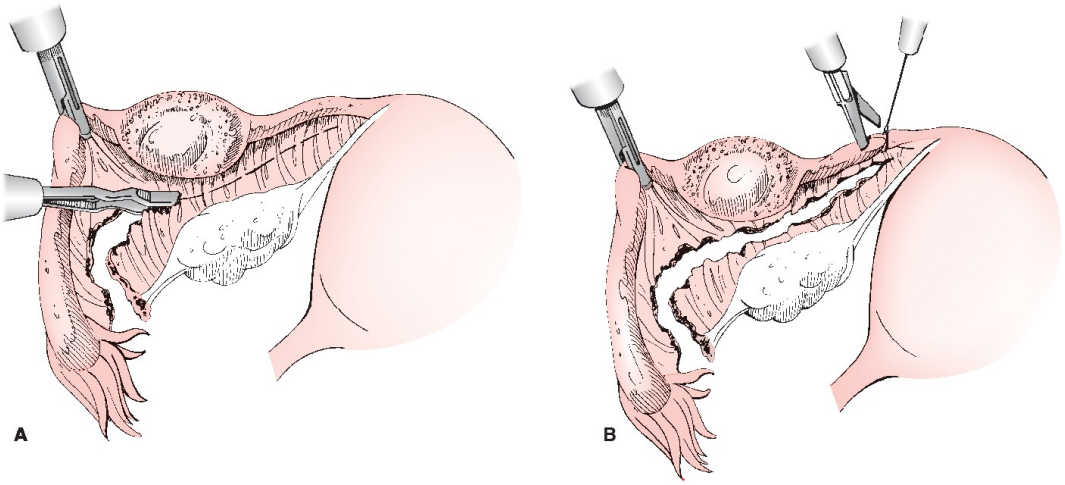



**FIGURE 20.6** Techniques of laparoscopic salpingectomy using bipolar cautery and

excision. **A.** Serially desiccate and cut across the mesosalpinx toward the tubal isthmus using an electrosurgical device, taking care to avoid compromising the blood supply to the ovary. **B.** Cross the tube at its proximal edge, desiccate, and excise the tube.

Laparoscopy is the optimal surgical approach when performed by an experienced surgeon, even in the case of a ruptured ectopic pregnancy with hemoperitoneum. When salpingostomy was compared via laparoscopy and laparotomy in randomized controlled trials, laparoscopy resulted in overall lower cost with shorter operative time, lower blood loss, and shorter length of stay and recovery time. Tubal patency, subsequent intrauterine pregnancy, and repeat ectopic pregnancy rates were similar for the two types of entry. Conversion of laparoscopy to laparotomy occurs rarely in 1% of cases.

In a systematic review of fertility outcomes after salpingostomy vs salpingectomy, two randomized controlled trials enrolled 575 women; subsequent intrauterine pregnancy and repeat ectopic pregnancy rates were similar at 24-36 months. Salpingostomy requires conversion to salpingectomy for persistent intraoperative bleeding in up to 20% of cases. Salpingostomy is also associated with a 3%-20% risk of persistent trophoblast, requiring ongoing monitoring, repeat surgery (4%), or MTX administration.

The ideal surgical approach depends on the patient's history and future fertility desires, patient and surgeon preference, and intraoperative findings. As salpingostomy does not result in a higher subsequent spontaneous intrauterine pregnancy rate and may require concurrent or subsequent MTX administration to prevent or manage persistent trophoblastic tissue, laparoscopic salpingectomy is the preferred surgical approach if the contralateral tube appears healthy. This preference is reflected in claims data that reveal an

increase in salpingectomy compared to salpingostomy, reaching 94% in 2015.

The technique for laparoscopic salpingectomy is summarized in **BOX 20.1**. After entering the abdominopelvic cavity via preferred laparoscopic approach, grasp the distal end of the fallopian tube with blunt forceps to expose the mesosalpinx. Perform adhesiolysis as necessary. If using an electrosurgical device, place it across the distal mesosalpinx, close to the fallopian tube to avoid compromising the blood supply to the ovary. Serially desiccate and cut as you move proximally to the tubal isthmus. Cross the tube at its proximal edge, desiccate, and excise the tube. If using pretied endoscopic ligatures, pass the distal end of the tube through the ligature and pull on the distal end while tightening the knot at the proximal edge of the fallopian tube, taking care to include the entire ectopic pregnancy. Repeat with a second ligature distal to the first. Use laparoscopic scissors to excise the tube distal to the sutures. Place the specimen in an endoscopic bag and remove it via a laparoscopic port site. Remove instruments and close the port sites.

# BOX 20.1 STEPS IN THE PROCEDURE

## Laparoscopic salpingectomy

- Grasp the distal end of the tube with blunt forceps to expose the mesosalpinx.

**With an electrosurgical device**

- Place the electrosurgical device across the distal mesosalpinx, close to the tube to avoid compromising blood supply to the ovary.
- Desiccate and cut as you move across the mesosalpinx to the tubal isthmus.
- Cross the tube at its proximal edge, desiccate and excise the entire tube.

**With pretied endoscopic ligatures**

- Pass the distal end of the tube through a pretied ligature.
- Tighten the knot at the proximal edge of the fallopian tube.
- Place a second ligature distal to the first.
- Excise the tube distal to the sutures.
- Place the specimen in an endoscopic bag and remove.

## Laparoscopic salpingostomy

- Grasp the distal end of the tube with blunt forceps.
- Inject dilute vasopressin into the mesosalpinx.
- Using an energy source to minimize tissue damage and bleeding, make a linear incision on the antimesenteric side of the distended tube at the presumed ectopic pregnancy site.
- Express the products of conception bluntly using pressure, forceps, suction, or hydrodissection.
- Irrigate the lumen with lactated Ringer solution to ensure complete removal of trophoblastic remnants.
- If products of conception are not clearly seen, collect clot for evaluation.
- Place the specimen in an endoscopic bag and remove.
- Obtain hemostasis with bipolar coagulation.
- Allow the tube to heal by secondary intention.

If the contralateral tube appears damaged or is absent or there is history of infertility in the absence of other risk factors, laparoscopic salpingostomy represents an alternative tubal-sparing approach. Given the high rate of persistent trophoblastic tissue with this approach, prophylactic systemic MTX should be administered within 24 hours of surgery and serum hCG levels monitored until undetectable.

The technique for laparoscopic salpingostomy is summarized in **BOX 20.1**. After entering the abdominopelvic cavity via preferred

laparoscopic approach, elevate the distal end of the fallopian tube with blunt forceps. To minimize the need for electrocoagulation for hemostasis, inject dilute vasopressin (eg, 5 units diluted in 20 mL normal saline) into the mesosalpinx proximal and distal to the ectopic. Because of its vasoconstrictive effect, relative contraindications to vasopressin include history of coronary artery disease, heart failure, chronic nephritis, migraine, seizure disorder, and asthma; care should be taken to not inject vasopressin directly into blood vessels. Using an energy source to minimize tissue damage and bleeding, make a salpingostomy incision in the most prominent part of the antimesenteric side of the fallopian tube. Use forceps, suction, or hydrodissection to separate the trophoblastic tissue from the tubal wall. Irrigate the tubal lumen with lactated Ringer solution to remove additional trophoblastic remnants. If products of conception are not clearly identified, collect any clot for evaluation. Place the specimen in an endoscopic bag and remove it via a laparoscopic port site. Obtain hemostasis with bipolar coagulation. Tubal suturing does not improve tubal patency, subsequent intrauterine pregnancy, or repeat ectopic pregnancy. Thus, allow the tube to heal by secondary intention. Remove instruments and close the port sites.

Salpingostomy should not be performed in the setting of a recurrent ectopic pregnancy in the same tube, a severely damaged tube, or ectopic pregnancy in someone who has completed childbearing.

When operating on a patient with an ectopic pregnancy and a history of prior bilateral tubal sterilization procedure, the best practice to reduce the risk of future ectopic pregnancies is to perform a total salpingectomy on the proximal bilateral tubal remnants; tuboperitoneal fistula has been demonstrated on the contralateral side.

Patients with contraindication to laparoscopy, such as severe pelvic adhesive disease, may be more suitable for treatment via minilaparotomy, which is associated with lower rate of ileus and wound infection and shorter operative time and length of stay than laparotomy.

Finally, while no studies compare expectant management and surgery, expectant management can be considered for selected asymptomatic patients willing to accept the risks of rupture, hemorrhage, and emergency surgery. At hCG levels <200 mIU/mL, resolution occurs in 88% of patients expectantly managed. Based on a systematic review and meta-analysis of randomized trials of tubal pregnancies at declining hCG levels <2000 mIU/mL or single hCG levels under 1500 mIU/mL, there is insufficient evidence that single-dose intramuscular MTX and expectant management have different resolution, avoidance of surgery, or time to resolution.

# CESAREAN SCAR PREGNANCY

Cesarean scar pregnancy is a rare type of ectopic pregnancy, up to 6% of all ectopic gestations, that occurs when a pregnancy implants within the myometrium at the site of a prior hysterotomy. Cesarean scar pregnancy is of particular concern as cesarean section rates increase worldwide. The incidence of cesarean scar pregnancy is 1:2216 deliveries and may be as high as 1:531 people with a prior cesarean.

Diagnosis is difficult as a cesarean scar pregnancy can be mistaken for a normal but low-lying pregnancy, cervical ectopic pregnancy, or a spontaneous abortion in progress. Ultrasound criteria include the following (**FIG. 20.7**):

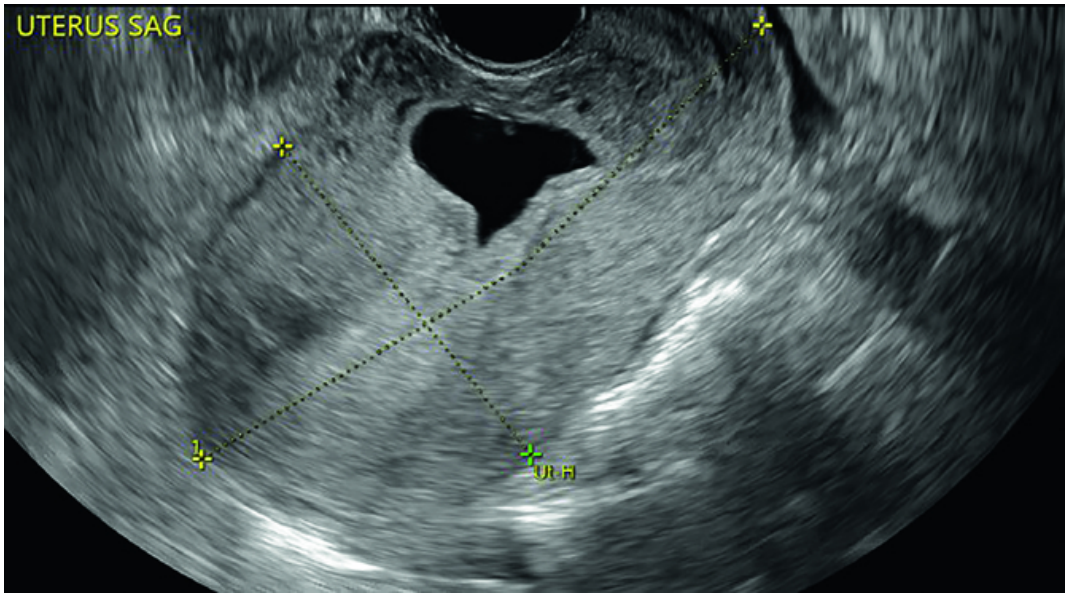



**FIGURE 20.7** Ultrasound image of a cesarean scar ectopic pregnancy. (Image courtesy of Dr. Paula Castaño.)

- An empty uterine cavity and endocervical canal
- A gestational sac/placental tissue in the anterior wall of the uterine isthmus
- Discontinuity on the anterior uterine wall
- Absent or diminished myometrium between the gestational sac/placental tissue and the bladder
- The presence of color Doppler flow at the hysterotomy site

Accurate and timely diagnosis is key, as a false-negative or delayed diagnosis can result in serious morbidity including hemorrhage, blood transfusion, uterine rupture, and emergency hysterectomy. Once cesarean scar pregnancy is diagnosed, we recommend prompt pregnancy termination.

Two types of cesarean scar pregnancy phenotypes exist: endogenic or type 1 (“on the scar”—growing in the uterine cavity with a considerable myometrial layer) and exogenic or type 2 (“in the niche”—growing toward the bladder or abdominal cavity with a thin myometrial layer).

The goals of treatment are prevention of complications and preservation of future fertility when desired. The majority of published treatment options are from case series. The best approach is yet to be determined and will depend on local resources and skill. Results of systematic reviews suggest that surgical management is preferred to medical management, but direct comparisons are limited. Treatments may evolve to include a combination of less-invasive approaches along with surgical management (due to risk of hemorrhage as the vascular trophoblastic tissue degenerates after medical management). Two recommended surgical approaches for management of cesarean scar pregnancy are hysterotomy and hysteroscopy. Both require an experienced surgeon. A cesarean scar pregnancy registry (csp-registry.com) seeks worldwide input on diagnosis and management of cases to promote research, identify treatments, and develop management guidelines. As the number of published cases of cesarean scar pregnancy increases, surgeons should review the latest literature to determine whether a new modality has emerged as a reasonable alternative.

Hysterotomy, best approached via laparoscopy, is preferable as it allows for both removal of the pregnancy and repair of the myometrial defect, although effect on recurrence risk is unknown. It is the preferred surgical approach in exogenic pregnancies, when the thickness of the myometrial wall between the sac and the bladder is <3 mm. It is also the mandatory approach when uterine rupture is suspected. Hysterotomy is successful in 92% of cases and has a hysterectomy rate of <2%.

The technique for laparoscopic excision of a cesarean scar ectopic pregnancy is summarized in **BOX 20.2**. After entering the abdominopelvic cavity via the preferred laparoscopic approach, use sharp and blunt dissection to free the bladder from the front of the uterus at the level of the vesicouterine peritoneum. Injection of dilute vasopressin or ligation of the ascending branches of the uterine vessels may aid with hemostasis. Identify the area of the cesarean scar pregnancy defect and open it via hysterotomy. Remove the gestational tissue and place the specimen in an endoscopic bag and remove it via a laparoscopic port site. Resect the serosa and myometrium around the pregnancy site until normal anatomy is

revealed. Obtain hemostasis with judicious bipolar coagulation. Repair the uterine defect with interrupted 0 absorbable suture. Remove instruments and close the port sites.

## BOX 20.2 STEPS IN THE PROCEDURE

### Excision of Cesarean Scar Ectopic Pregnancy via Laparoscopy

- Dissect the bladder free of the front of the uterus at the level of the vesicouterine peritoneum.
- If desired, inject dilute vasopressin or ligate the ascending branches of the uterine vessels to aid with hemostasis.
- Identify and open the area of the cesarean scar pregnancy.
- Remove the gestational tissue.
- Remove products of conception in an endoscopic bag.
- Define the cesarean scar pregnancy defect and resect the serosa and myometrium around the cesarean scar pregnancy until normal anatomy is revealed.
- Obtain hemostasis with bipolar diathermy.
- Repair the uterine defect with endoscopic suturing with interrupted 0 absorbable suture.

Patients with contraindication to laparoscopy, such as severe pelvic adhesive disease, may be more appropriate for hysterotomy management via minilaparotomy. A transvaginal approach via an anterior colpotomy appears promising with a <1% complication rate in limited case series but requires a skilled transvaginal surgeon; more research is needed before it can be recommended as an alternative approach to hysterotomy.

Hysteroscopy is a less invasive surgical option that may be considered in endogenic pregnancies, when the thickness of the myometrial wall between the sac and the bladder is ≥3 mm.

Hysteroscopic removal, with or without ultrasound or laparoscopic guidance, has low complication rates of 3%-20%, but secondary treatment may be necessary in 12%-61% of cases. An operative hysteroscope is introduced to confirm location of the gestational tissue. The implantation site vessels are electrocoagulated with the bipolar rolling ball. The uterine contents are removed or aspirated. The hysteroscope is reintroduced to confirm clearance of gestational tissue. Hemostasis is obtained with electrocoagulation or intrauterine Foley balloon.

Ultrasound-guided vacuum aspiration is another surgical option in settings where hysterotomy or hysteroscopy are not feasible. Vacuum aspiration is more successful in earlier endogenic pregnancies. We recommend proceeding only if a plan for management of hemorrhage exists and after adding vasopressin to the paracervical block (eg, 4 units in 20 cc anesthetic solution). In a series of management via ultrasound-guided aspiration, 5% required blood transfusion, 6% underwent a repeat surgery, and only one of 191 patients had a hysterectomy.

Local or intragestational MTX injection may be a medical management option for stable patients willing to accept 60%-80% efficacy and a 4% serious complication rate, and when anatomy makes this option feasible. It is usually administered in doses of 1 mg/kg up to 50 mg via a 20-gauge needle under ultrasound guidance using a transvaginal approach. Sac aspiration before injection can help verify needle placement. Repeat doses may be needed. Pregnancy resolution, monitored by sonographic surveillance, may take months.

While considered the procedure of last resort, hysterectomy provides definitive treatment and may be necessary for those with uncontrollable hemorrhage, who do not desire future fertility or who have uterine conditions for which hysterectomy may be curative (eg, large symptomatic fibroids or adenomyosis).

Cesarean scar pregnancy represents a very early pathologically adherent placenta. When not diagnosed until later in pregnancy, patients may select expectant management after counseling. Spontaneous abortion in those undergoing expectant management is common, and emergency intervention is often required. Reports of

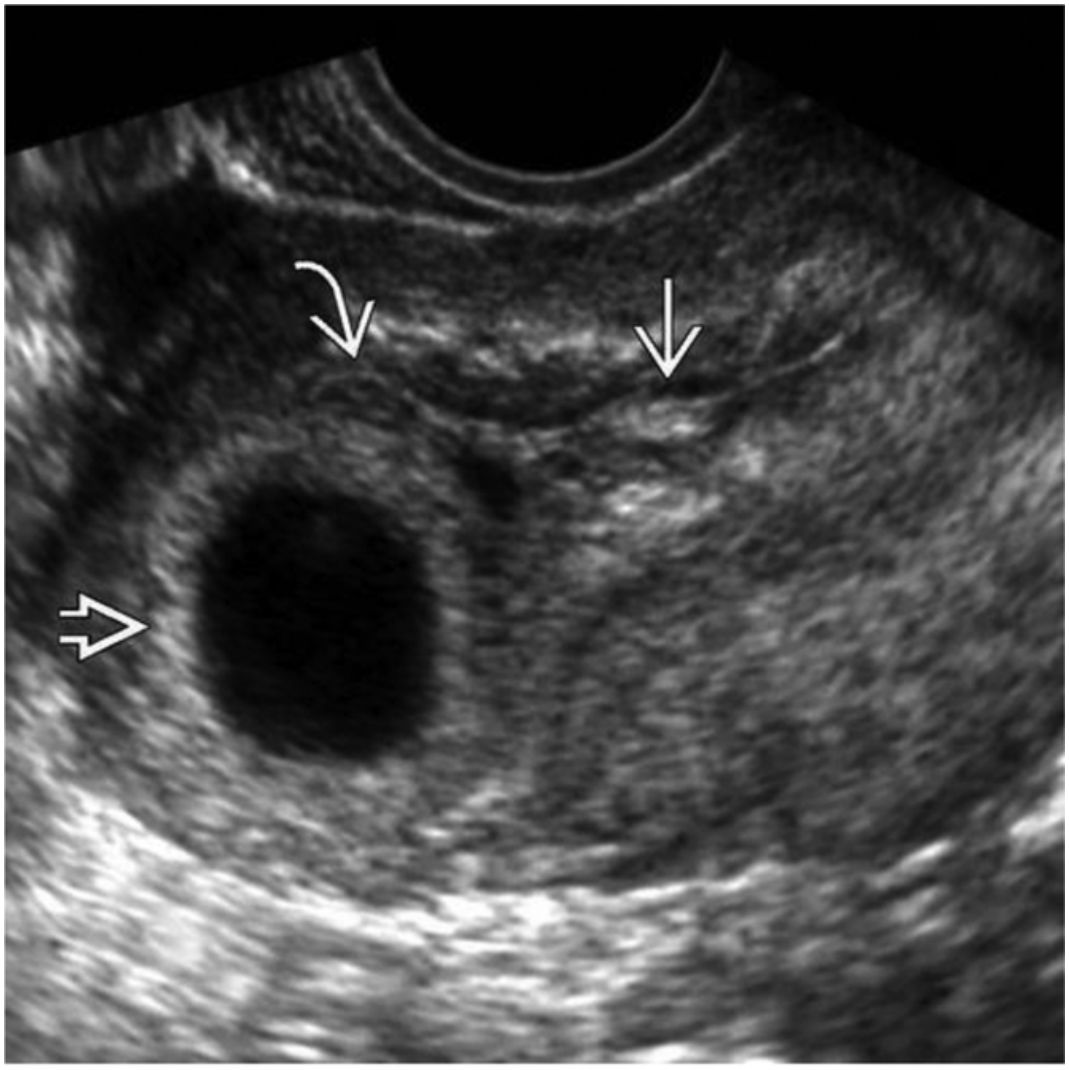
successful birth after expectant management of cesarean scar pregnancy highlight the serious risk of morbidity (54%-70%), including loss of pregnancy and loss of future fertility. Repeat cesarean delivery is recommended between 34 0/7 and 35 6/7 weeks gestation and only in facilities equipped to manage massive hemorrhage.

We do not recommend medical management with systemic MTX alone secondary to high likelihood of failure (75%-91%), 13%-62% complication rate, and 4% hysterectomy rate. Similarly, uterine artery embolization alone has a high failure rate (82%), high complication rate (80%), possible adverse impact on a subsequent pregnancy, and requires access to an interventional radiologist. We also do not recommend sharp curettage, as it is no longer the standard of care for management of miscarriage or abortion due to increased procedural risk.

# INTERSTITIAL PREGNANCY

Interstitial pregnancy is a rare but diagnostically challenging variant of ectopic pregnancy, representing 2%-4% of all ectopic gestations with a mortality rate as high as 2.5%. The intramural portion of the fallopian tube is relatively thick and possesses a significantly greater capacity to expand before rupturing than does the distal portion of the tube. Consequently, an interstitial pregnancy may remain asymptomatic until 7-16 weeks of gestation. The risk of morbidity and mortality is heightened by the prominent vascular anastomosis of the uterine and the ovarian arteries in this area, so rupture can result in catastrophic hemorrhage. Risk factors for interstitial pregnancy are similar to those for any ectopic gestation; the only risk factor unique to interstitial pregnancy is an ipsilateral salpingectomy.

High-resolution transvaginal ultrasound allows for diagnosis of interstitial pregnancy at early gestations, often before symptoms appear (**FIG. 20.8A-C**). Ultrasonographic criteria for a diagnosis of interstitial pregnancy include the following:



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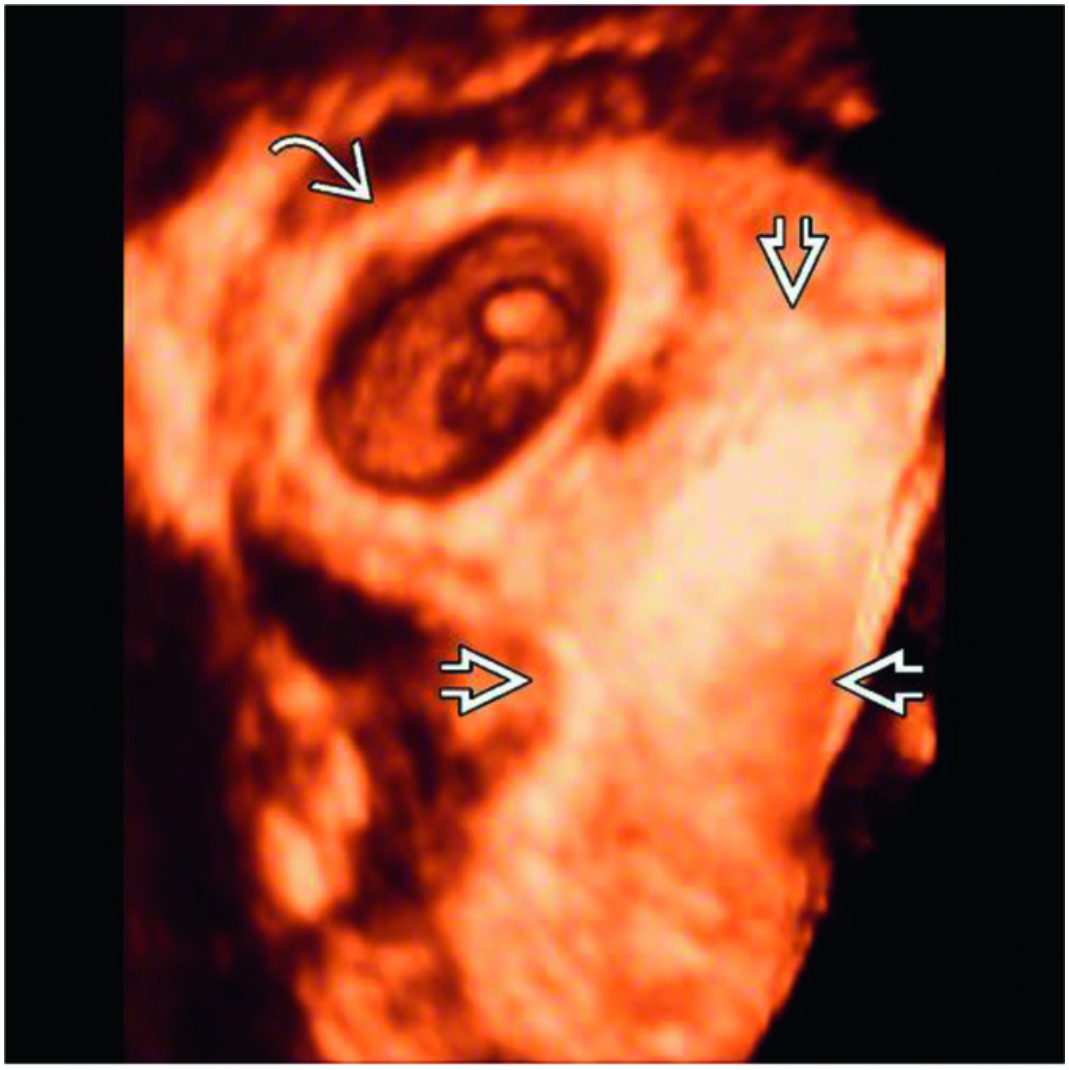

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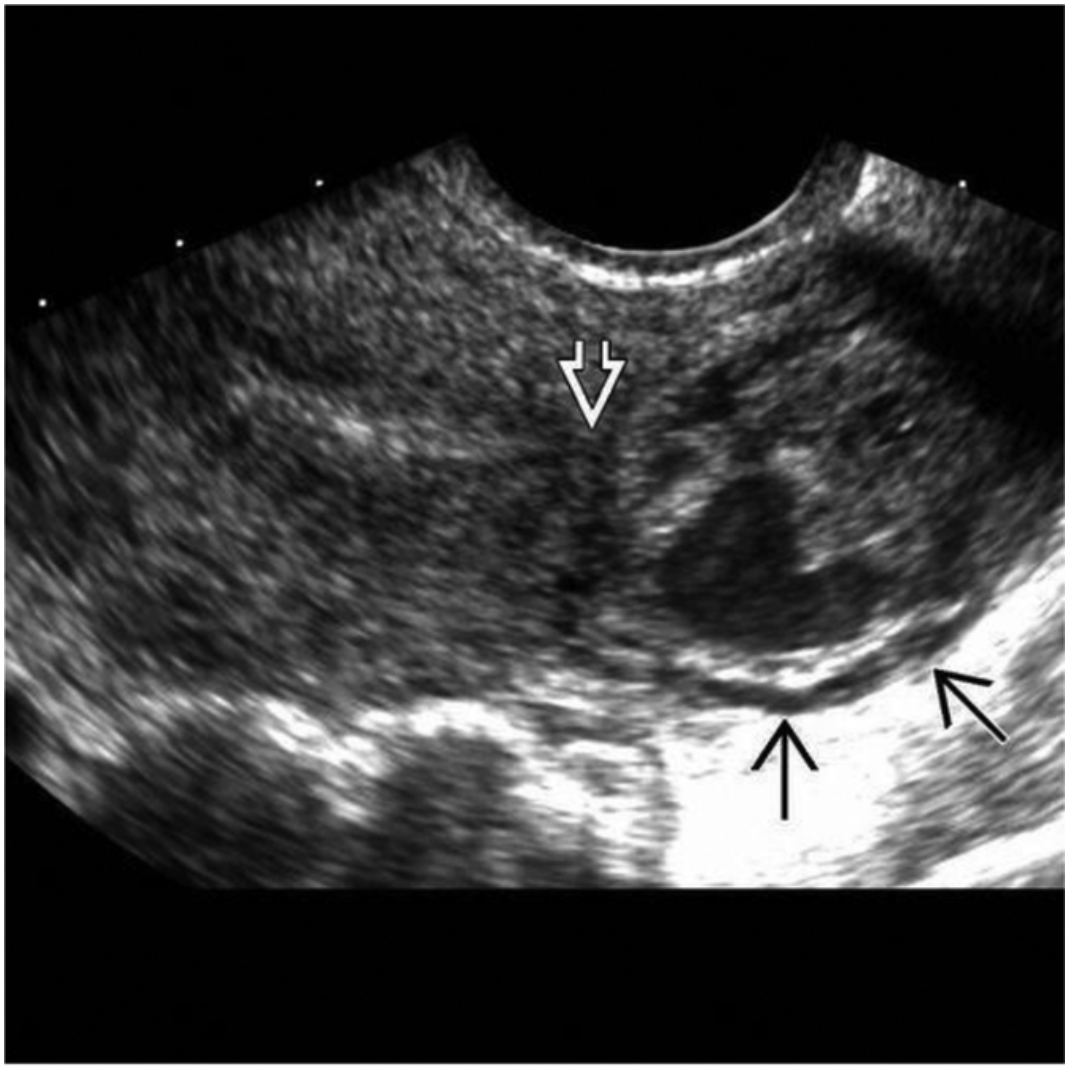


C

**FIGURE 20.8** Ultrasound images of interstitial pregnancies. **A.** Interstitial ectopic. The gestational sac (*double arrow*) is seen distinct from the endometrial line (*single arrows*). **B.** Coronal reformatting from 3D sonogram of the uterus shows that the gestational sac is located in the right cornua (*single arrow*). **C.** Transverse view of the uterus with the gestational sac (*single arrows*) visible in the

left cornua, distinct from the endometrial cavity (*double arrow*). (From Jeffrey RB, Manaster BJ, Osborn AG, Rosado-de-Christenson ML, Woodward PJ. *Diagnostic Imaging: Emergency*. 2nd ed. Wolters Kluwer; 2014. Figs. 4.6, 1.4, 4.3.)

- Absence of an intrauterine pregnancy
- A chorionic sac separate and at least 1 cm from the lateral edge of the uterine cavity
- A thin layer of myometrium surrounding the gestational sac measuring <5 mm
- "Interstitial line sign"—an echogenic line extending from the endometrial cavity to the uterine cornua, adjacent to the mass or gestational sac (**FIG. 20.8C**)

Despite these criteria, interstitial pregnancy is often missed; in a few series, the correct diagnosis was present before surgery in only 56%-71% of the reported cases.

The terms *cornual pregnancy* and *interstitial pregnancy* continue to be used interchangeably (and confusingly) in the medical literature and in clinical practice. The confusion is magnified since the surgery for an interstitial pregnancy is called a cornual resection. An interstitial pregnancy occurs when the fertilized egg implants in the most proximal section of the fallopian tube that is surrounded by myometrium; while these gestations are technically within the uterus, they are located outside the endometrial cavity. A cornual ectopic pregnancy, on the other hand, commonly yet incorrectly refers to a pregnancy located in the upper and lateral uterine cavity. Additionally, the term *angular pregnancy* is sometimes used to refer to a gestation along the lateral angles of the uterus medial to the internal ostium of the fallopian tube.

To prevent overlapping definitions and given the difference in management and outcomes between the two pregnancy locations,

we recommend that the designation “cornual” should be reserved for intrauterine pregnancies located in the horn of a unicornuate or bicornuate uterus. Further, we recommend use of the term “eccentric” to refer to gestations near the uterotubular junction that nonetheless are intrauterine. These pregnancies can be distinguished on ultrasound with use of the “double sac sign.” The presence of two concentric, sonolucent intrauterine rings surrounding the gestational sac, thought to represent an outer, normal peripheral decidual reaction and an inner chorionic ring, are consistent with an early intrauterine pregnancy. While many eccentric pregnancies will result in spontaneous abortion, many will be carried to term, so this pregnancy variant can be managed expectantly.

There is a scarcity of long-term data in relation to relative safety or fertility outcomes for either conservative or surgical approaches to interstitial pregnancy. For hemodynamically stable patients, conservative treatment by an experienced laparoscopic surgeon is the recommended surgical approach. Surgical treatment is additionally indicated when the patient is not interested in medical management, medical treatment has failed, or in cases of recurrent interstitial pregnancy. Laparoscopy offers several advantages over laparotomy, including reduced blood loss, shorter hospital stays, and faster recovery.

A key component of the minimally invasive approach is to achieve hemostatic control, as blood loss is higher in cases performed without techniques performed to reduce bleeding. Another key component is sufficient myometrial closure, to both achieve hemostasis and prevent uterine rupture in a subsequent pregnancy. Hemostatic sutures, whether interrupted, figures-of-8, or purse string, will achieve myometrial closure in one to two layers.

The preferred surgical approach to interstitial pregnancy is a laparoscopic cornuostomy or cornual resection (so named due to the general anatomic location of the pregnancy). There are few studies comparing these techniques in terms of short-term safety or long-term outcomes, including relative risk of uterine rupture in a subsequent pregnancy. In retrospective reviews, cornuostomy has comparable treatment and fertility outcomes to cornual resection,

and operating time was significantly shorter for cornuostomy procedures. Interestingly, there were no differences in the incidence of persistent interstitial pregnancy between groups, suggesting that cornual resection does not completely prevent persistent interstitial pregnancy.

To perform a laparoscopic cornuostomy, first inject dilute vasopressin circumferentially into the myometrium surrounding the ectopic until uterine blanching is noted. We recommend injection of vasopressin, most often 10-20 units diluted in 30-100 mL of normal saline. For surgeons who prefer to inject a larger volume, injection of 150-250 mL of highly dilute vasopressin—20 units in 1000 mL—has been reported. Next, make a linear incision in the most bulging aspect along the long axis of the pregnancy with monopolar scissors. Remove the products of conception with hydrodissection, grasping forceps, or aspiration and then irrigate the cavity with high hydrostatic pressure. Any bleeding at the base of the myometrium can be controlled with judicious bipolar cautery as needed. Excise the minimum myometrium needed to reapproximate viable tissue. Close the incision with interrupted absorbable sutures—vertical mattress sutures, suture loop, or purse string. If the interstitial pregnancy is small and superficial, the myometrium may be able to be closed with a surgical stapler (**BOX 20.3**).

## BOX 20.3 STEPS IN THE PROCEDURE

### Cornuostomy via Laparoscopy

- Inject dilute vasopressin into the myometrium surrounding the ectopic until uterine blanching is noted.
- Make a linear incision in the most bulging aspect along the long axis of the pregnancy with monopolar scissors.
- Remove the products of conception with hydrodissection, grasping forceps, or aspiration.
- Irrigate the cavity with high hydrostatic pressure.

- Obtain hemostasis at the base with judicious bipolar cautery as needed.
- Close the incision with interrupted absorbable suture—vertical mattress sutures, suture loop, or purse string.
- If the interstitial pregnancy is small and superficial, the myometrium may be able to be closed with a surgical stapler.

## Cornual Resection via Laparoscopy

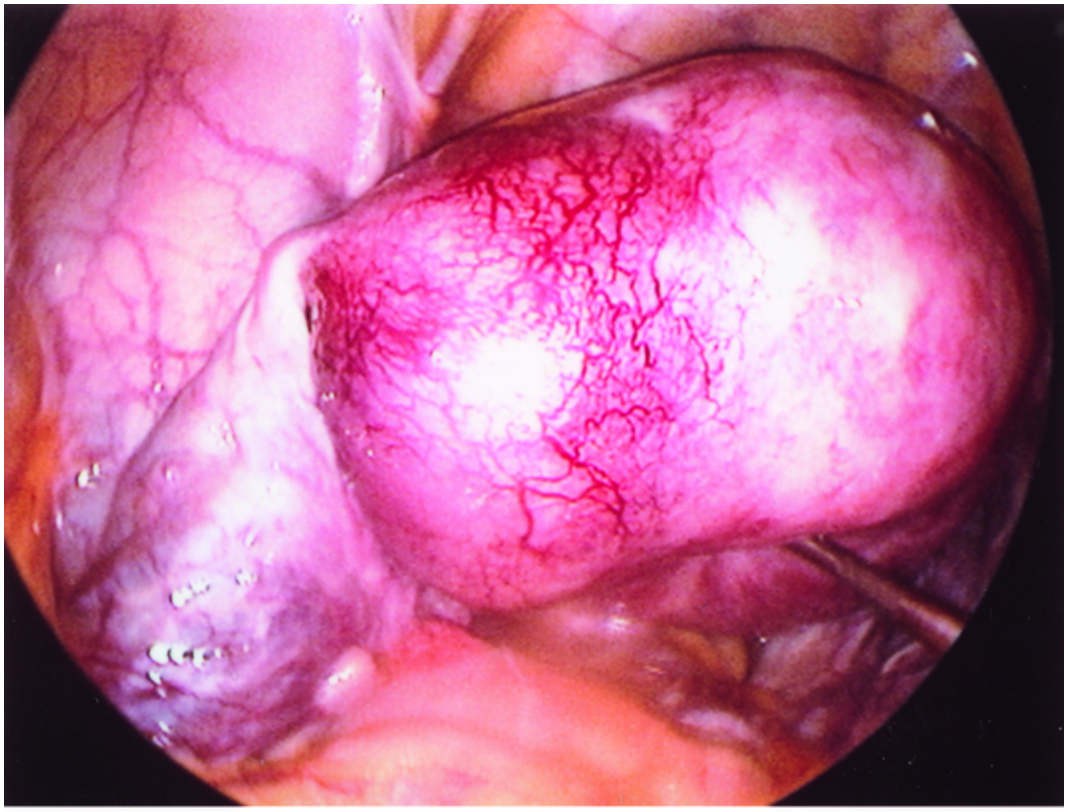
- If desired, place a purse string suture around the base of the pregnancy.
  - Inject dilute vasopressin into the myometrium at the base of the ectopic until uterine blanching is noted.
- If desired, ligate the ascending branches of the uterine vessels.
- Incise around the interstitial pregnancy in a deep circumferential manner with monopolar scissors, 1-2 cm above the base to allow sufficient serosa and myometrium for closure.
  - If needed, transect the ipsilateral fallopian tube and mesosalpinx with electrosurgery.
- Remove the products of conception and surrounding myometrium with an energy source (bipolar, harmonic scalpel, or electrothermal bipolar vessel sealing device).
  - If desired, perform salpingectomy with electrosurgery.
- Place specimen in an endoscopic bag.
- Debride the tissue margins if necessary.
- Obtain hemostasis with judicious bipolar cautery.
- Close the myometrial defect in one to three layers via intra- or extracorporeal knot tying with absorbable sutures (interrupted, figure-of-8 or running layer of barbed suture).

There are no data about fertility outcomes between removal of the ipsilateral fallopian tube or leaving it in place. With large interstitial

pregnancies, the tube will often need to be removed, and theoretically, salpingectomy may reduce the recurrence of ectopic pregnancy on that side.

The persistence of interstitial pregnancy has been reported in 4%-17% of cases after conservative laparoscopic surgery. Follow-up of serum hCG levels is recommended; if levels rise or do not decline appropriately after the procedure, the use of adjuvant MTX can be an alternative to a repeat surgery for asymptomatic patients. MTX may also be used prophylactically after surgery for cases in which the gestational sac was large or if there is doubt about complete evacuation of the pregnancy.

For larger interstitial pregnancies, or for tissue that is too difficult to reapproximate, a cornual resection may be performed (**FIG. 20.9**). First, inject dilute vasopressin circumferentially into the myometrium at the base of the ectopic until uterine blanching is noted. If desired, place a purse string suture around the base of the pregnancy. Incise around the interstitial pregnancy in a deep circumferential manner with monopolar scissors; make the incision 1-2 cm above the base of the pregnancy to allow sufficient serosa and myometrium for closure. Alternatively, first make a single linear incision cornuostomy and then excise nonviable myometrial tissue on both sides at the base in an elliptical fashion. If needed, transect the ipsilateral fallopian tube and mesosalpinx with electrosurgery. Remove the products of conception and surrounding myometrium with an energy source (bipolar, harmonic scalpel, or electrothermal bipolar vessel sealing device) and place in an endoscopic bag. Once hemostasis is controlled, salpingectomy via electrosurgery can be completed. Returning to the site of the ectopic pregnancy, debride the tissue margins if necessary and control bleeding with judicious bipolar cautery. Close the myometrial defect in one to three layers via intra- or extracorporeal knot-tying with absorbable sutures (interrupted, figure-of-8 or running layer of barbed suture) or a surgical stapler if the incision permits.



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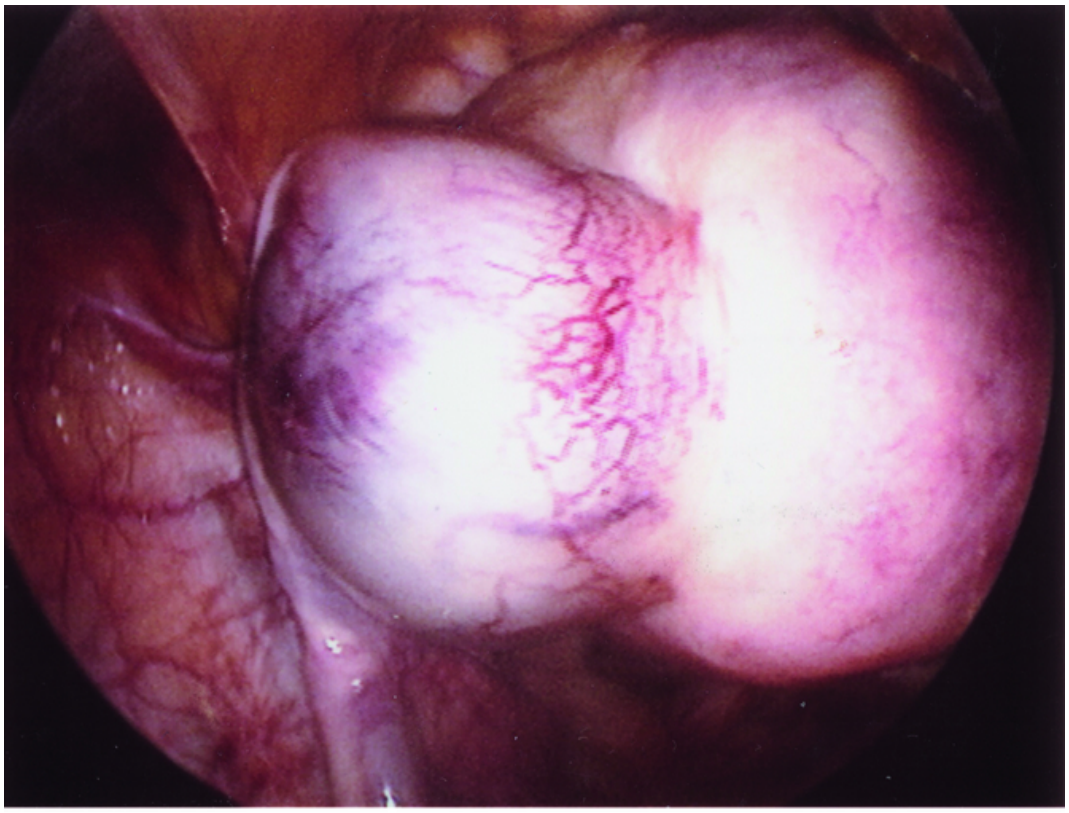

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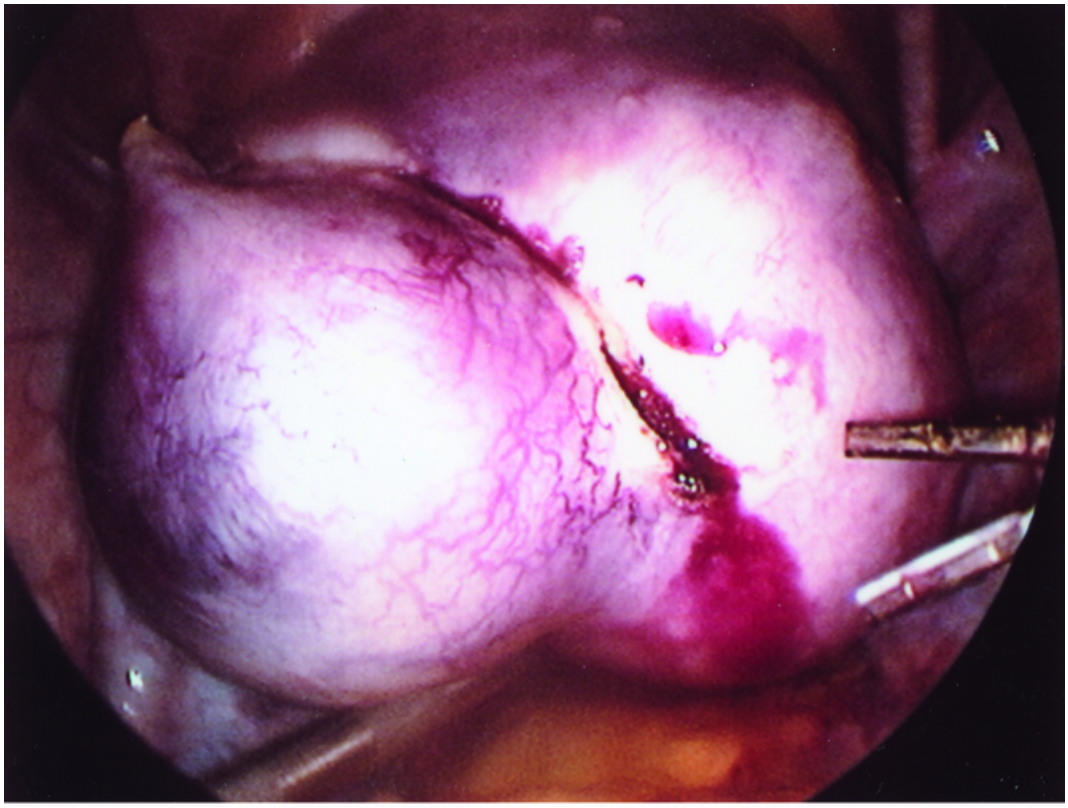

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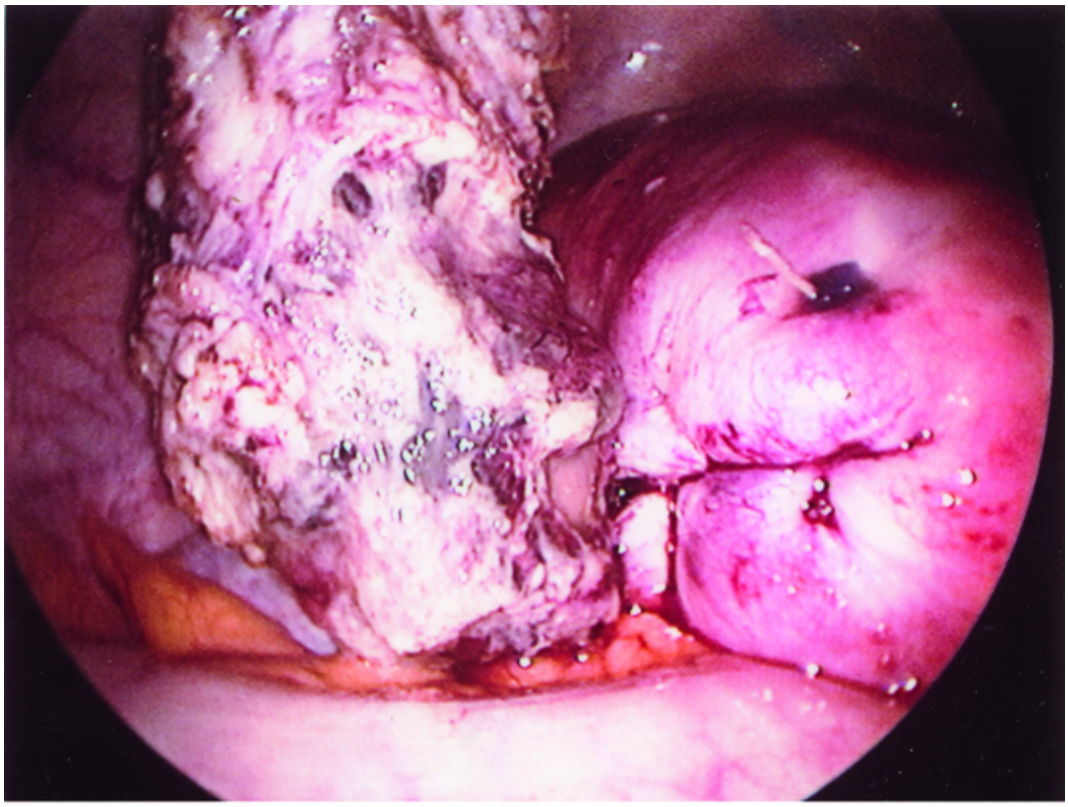

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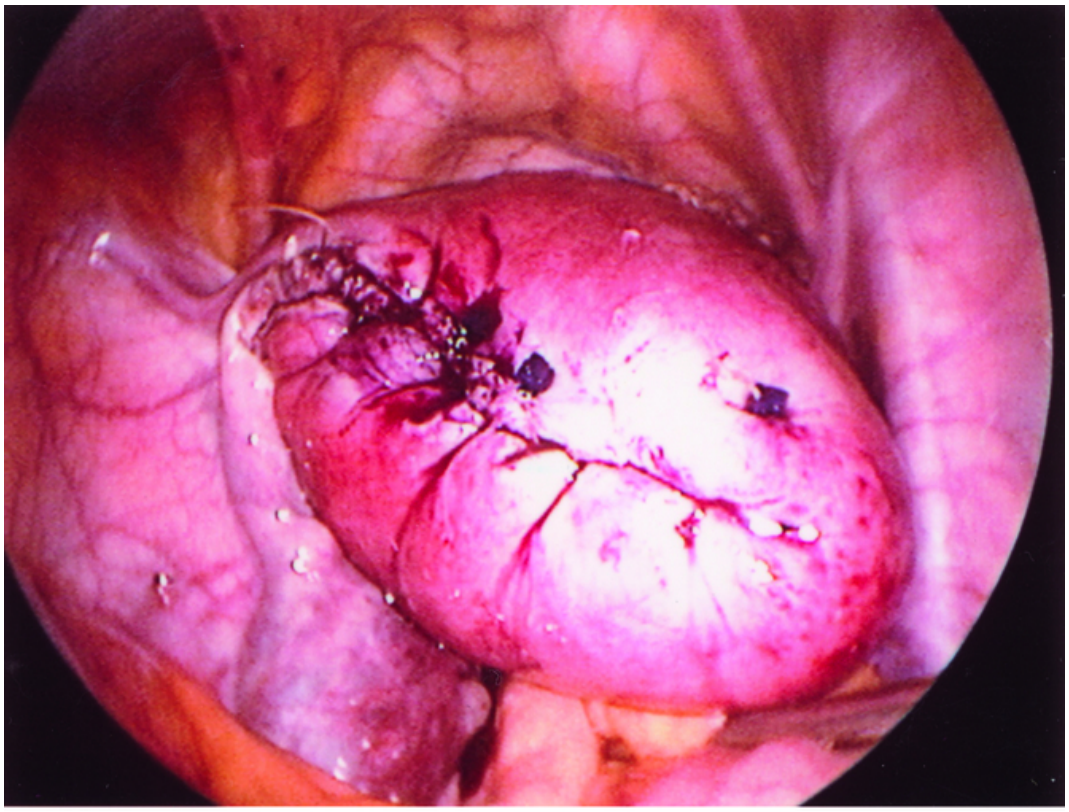

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**FIGURE 20.9** Laparoscopic cornual resection of left interstitial ectopic. **A.** An interstitial pregnancy on the left side of the uterus. **B.** Uterine blanching after vasopressin injection. **C.** Incision made at the junction of the uterus and the interstitial pregnancy with a harmonic scalpel. **D.** Removal of the cornua containing the pregnancy; the gestational sac is visible intact within the myometrium. The hysterotomy repair site is visible to the right of the specimen. **E.** Uterine incision after laparoscopic closure. (Images courtesy of Dr. Paul Hendessi.)

If the interstitial pregnancy is diagnosed early, and the gestational sac is small, systemic or local MTX is an option for interstitial pregnancy, either as the lone treatment or as an adjunct in advance of a surgical procedure. Success rates of medical management with MTX may exceed 90%, though the treatment period is long, and the risk of uterine rupture persists throughout treatment.

A transcervical surgical approach may be possible for certain interstitial pregnancies where continuity of the gestational sac with the endometrial stripe can be visualized by ultrasound. There are multiple reports and small case series of dilation and curettage or extraction utilizing various instruments placed under ultrasonographic or hysteroscopic guidance (or both): manual vacuum aspiration with a small flexible or rigid cannula, curved polypectomy forceps, urologic stone retrieval basket, and hysteroscopic grasping forceps (sometimes with the aid of ultrasound guidance). Laparoscopic guidance may be added. In evaluating patients to determine if a transcervical approach is feasible, consultation with specialists in complex family planning and reproductive endocrinology may be invaluable. There are minimal data about the risk of persistent interstitial pregnancy with a transcervical approach, or if there are any benefits in terms of patency of the tube and recurrent ectopic pregnancy.

Alternative hemostatic techniques other than vasopressin may occasionally be indicated. If a patient has a contraindication to vasopressin, a purse-string suture can be placed around the base of the interstitial pregnancy via laparoscopic suturing to cause vascular compression. We do not recommend electrocoagulation or fibrin glue as techniques to achieve *primary* hemostasis during a surgical procedure for interstitial pregnancy. Use of excessive bipolar cautery or harmonic scalpel can cause thermal damage to the myometrium, though judicious use for secondary hemostasis is acceptable. Fibrin glue used to seal the myometrium is often not sufficient to achieve hemostasis given the extremely vascular nature of an interstitial pregnancy.

Laparotomy is an acceptable approach if laparoscopic expertise is unavailable, or when a patient is hemodynamically unstable from a

presumed uterine rupture and timely laparoscopy cannot be performed.

While considered the procedure of last resort, hysterectomy may be necessary for patients with uncontrollable hemorrhage or very large interstitial pregnancies where uterine closure is not technically feasible after cornuostomy or wedge resection. Patients who do not desire future fertility or who have other uterine conditions for which hysterectomy may be curative (eg, large symptomatic fibroids or adenomyosis) may elect this approach even in the absence of a surgical emergency.

# OVARIAN PREGNANCY

The incidence of ovarian pregnancy ranges from 1:3000 to 1:40 000 deliveries and represents 1%-3% of all ectopic pregnancies. Increased use of IUDs and artificial reproductive technologies has increased the proportion of ectopic pregnancies that are ovarian.

The most common presenting symptom is pain. Ultrasound is increasingly helpful in diagnosis, and ovarian ectopic pregnancy should be suspected when sonography in a pregnant woman reveals no intrauterine pregnancy in the setting of a complex ovarian mass. Ultrasound diagnostic criteria proposed by Comstock and colleagues and Ghi and colleagues include the following:

- A wide echogenic ring with an internal echolucent area on the surface of the ovary
- Echogenicity of the ring greater than that of the ovary
- Presence of ovarian cortex around the mass

An ovarian ectopic pregnancy can be confused with a tubal ectopic pregnancy, a corpus luteum, or a hemorrhagic cyst on ultrasound. 3D ultrasound may augment conventional ultrasound in differentiating an ovarian ectopic pregnancy from cysts.

Diagnosis is still often made intraoperatively (**FIG. 20.10**) and confirmed postoperatively by Spiegelberg Criteria:

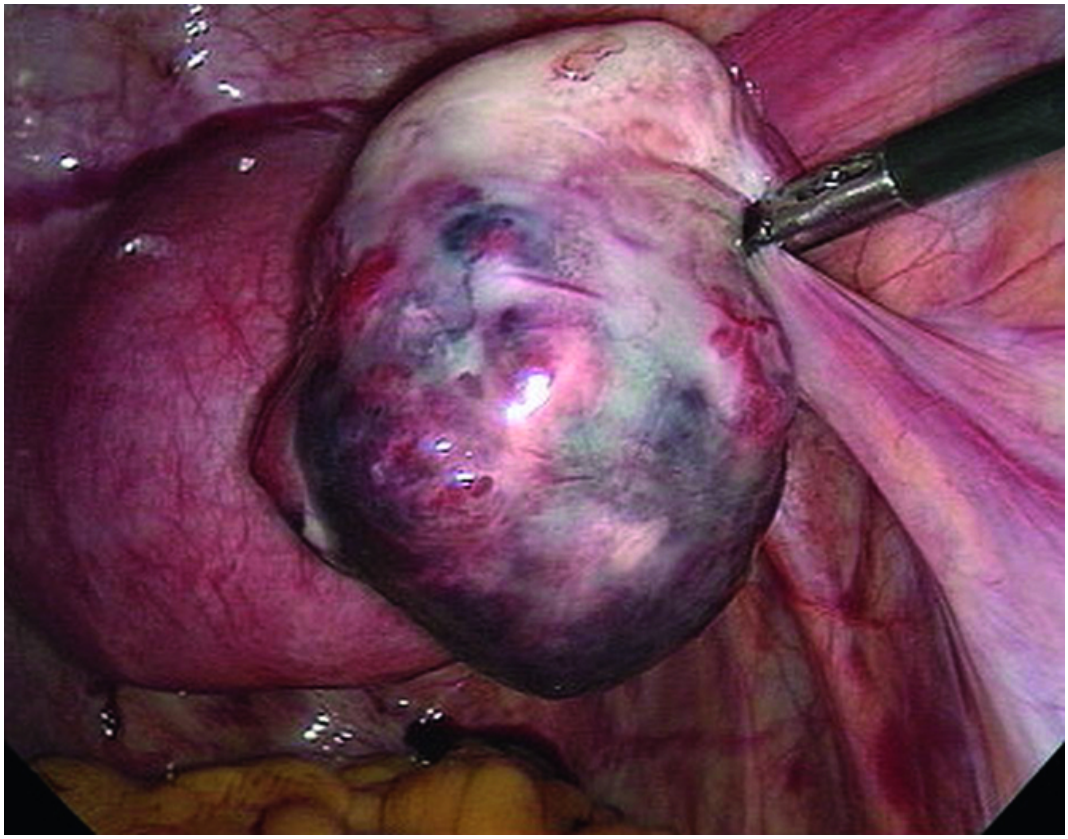

**FIGURE 20.10** Laparoscopic image of ovarian pregnancy. (Reprinted from Kraemer B, Kraemer E, Guengoer E, et al. Ovarian ectopic pregnancy: diagnosis, treatment, correlation to Carnegie stage 16 and review based on a clinical case. *Fertil Steril*. 2009;92(1):392.e13-392.e15. Copyright © 2009 American Society for Reproductive Medicine. With permission.)

- The fallopian tube and fimbria are intact and separate from the ovary.
- The gestational sac occupies the normal position of the ovary.
- The ovary and gestational sac are connected to the uterus by the utero-ovarian ligament.

- Ovarian tissue is attached to the gestational sac specimen.

Surgical management is preferred; the primary goal of management is to remove the ectopic pregnancy while preserving the ovary. Compared to tubal ectopic pregnancy, surgical management of ovarian ectopic pregnancy is associated with higher blood loss, more transfusions, and longer hospital stay. Patients with signs of hemodynamic instability demand surgical management, which is possible via laparoscopy by a skilled surgeon. This can be accomplished via trophoblast dissection off the ovary or ovarian wedge resection if the ectopic mass is large. Typically, oophorectomy is only indicated if a patient requests ovarian removal or has coexisting ipsilateral ovarian pathology or the surgeon encounters excessive bleeding.

The technique for laparoscopic dissection of the trophoblast off the ovary is summarized in **BOX 20.4**. After entering the abdominopelvic cavity via preferred laparoscopic approach, grasp the ovary and sharply or bluntly dissect the affected area of the ovary using scissors or an energy source (bipolar, harmonic scalpel, or electrothermal bipolar vessel sealing device). Place the specimen in an endoscopic bag and remove it via a laparoscopic port site. Control bleeding with judicious bipolar cautery or sutures. Remove instruments and close the port sites.

## BOX 20.4 STEPS IN THE PROCEDURE

### Trophoblast Dissection off the Ovary via Laparoscopy

- Explore the pelvic anatomy to exclude other locations of the ectopic pregnancy.
- Grasp the ovary and sharply or bluntly dissect the affected area of the ovary using scissors and/or cautery.
- If conservative dissection fails or is deemed impossible, incise in a wedge-shaped manner around the pregnancy using

electrocautery.

- Place the specimen in an endoscopic bag and remove.
- Obtain hemostasis with coagulation or sutures.

If the conservative dissection approach is unsuccessful or the ectopic is large, ovarian wedge resection may be necessary. In this case, the surgeon should follow the initial steps for dissection but then use electrocautery to incise a wedge-shaped area around the ectopic.

Conservative surgical resection or dissection may result in remaining trophoblastic tissue, which must be monitored via quantitative beta hCG and managed medically with systemic MTX. Primary medical management with systemic MTX may be considered in patients who are high-risk surgical candidates, although treatment failure is high. The utilization of this option may increase as improved ultrasound allows for earlier diagnosis. Recurrence risk appears low, but data on future fertility are lacking.

# CERVICAL PREGNANCY

Cervical pregnancy, implantation of the pregnancy below the level of the internal cervical os, is a rare but life-threatening condition. The incidence of cervical pregnancy is ~1:10 000 pregnancies and represents <1% of all ectopic gestations. Chorionic villi can easily erode through the cervical stroma, due to the lack of a protective decidual plate, leading to catastrophic bleeding. As contraction of the cervix is poor due to lack of muscle fibers, hemostasis is difficult to achieve once hemorrhage begins. Consequently, prompt and correct diagnosis of cervical pregnancy is essential for appropriate treatment to reduce maternal morbidity and mortality.

The incidence of cervical pregnancy is higher among patients using assisted reproductive technology (ART)—3.5/10 000, or 2% of the ectopic pregnancies. Other risk factors include multiparity, prior uterine or cervical instrumentation, anatomic abnormalities (leiomyomata, synechiae), prior ectopic pregnancy, and prior cesarean delivery. Among people undergoing ART, having had two

or more previous miscarriages and cigarette smoking were additional risk factors.

The most common presentation of cervical pregnancy is a history of painless vaginal bleeding after a period of amenorrhea, with an enlarged congested cervix on exam. Cervical pregnancies are now diagnosed earlier in gestation due to better diagnostic modalities and greater clinician awareness. Ultrasound diagnostic criteria include the following (**FIG. 20.11**):

**FIGURE 20.11** Ultrasound image of cervical pregnancy. Transvaginal ultrasound image showing 1.7-cm large gestational sac within the cervix. Uterus and cervix, sagittal view. (Reprinted with permission from Alammari R, Thibodeau R, Harmanli O. Vaginal hysterectomy for treatment of cervical ectopic pregnancy. *Obstet Gynecol*. 2017;129(1):63-

65. Copyright © 2016 by The American College of Obstetricians and Gynecologists.)

- Absence of an intrauterine pregnancy
- Dilated and barrel-shaped cervix (leading to an “hourglass” appearance of the uterus and cervix)
- Gestational sac or placental texture present within the cervix below the internal cervical os or uterine arteries
- Absence of a “sliding sign” (when an expelling gestational sac slides against the endocervical canal with gentle pressure on the cervix with the vaginal probe, which does not occur with an implanted cervical pregnancy)
- Presence of blood flow around the gestation sac using color Doppler flow

A sonographic impression of cervical pregnancy is correct in most cases, though magnetic resonance imaging may be helpful when the ultrasound is inconclusive.

Patient presentation at time of diagnosis is the driving factor in management. Other factors include experience of the surgeon, availability of hospital resources, and timing of diagnosis. The goals of treatment are to resolve the cervical pregnancy, minimize hemorrhage, and if desired, preserve fertility. For some patients, a surgical approach may be preferred, either due to hemodynamic instability or an unwillingness to accept the risks of more conservative approaches. There is no consensus or published guidelines on the optimal therapy, as all published reports are retrospective. A 2021 review (Fowler) of 204 published articles comprising 454 cases of cervical ectopic pregnancies assessed the likelihood of initial treatment success for a variety of treatment modalities (systemic methotrexate, uterine artery embolization, D&C (dilation and curettage), potassium chloride, methotrexate with uterine artery embolization, D&C with uterine artery embolization, and other). Lower initial treatment success was found for patients with serum hCG levels >30 000 (OR 0.4, 95% CI, 0.19-0.84) or with the presence of fetal cardiac activity (OR 0.5, 95% 0.31-0.8). Higher

initial treatment success was found for D&C (OR 2.26; 95% CI, 2.64-10.45), D&C with uterine artery embolization (OR 4.85; 95% CI, 2.06-11.44), and uterine artery embolization alone (OR 5.17; 95% CI, 1.14-23.53). The authors concluded that management of cervical ectopic pregnancies should be guided by patient stability, hCG level, size of pregnancy, and fetal cardiac activity and may benefit from a planned multimodal approach.

Surgeons should anticipate the possibility of significant bleeding, and preoperative measures should be taken to prevent hemorrhage to reduce morbidity. Prior to any procedure, clinicians should have blood products available and patients should understand the potential need for hysterectomy if less invasive treatments fail.

For the treatment of cervical pregnancy, we recommend vacuum aspiration in conjunction with a preoperative intervention to decrease vascularization of the mass, to minimize the risk of heavy bleeding and maximize the chance of future pregnancy. The most conservative preoperative approach is uterine artery embolization (UAE). Preoperative embolization minimizes the risk of massive bleeding during surgery, though patients may require blood transfusion while awaiting treatment. Menses should return within 3 months of treatment. There are limited data about fertility following uterine artery embolization for cervical pregnancy, but fertility appears improved with the use of temporary embolic agents.

For patients with a planned surgical intervention who strongly desire fertility and are not comfortable with the unknown effects of uterine artery embolization on future childbearing, we recommend MTX and/or vasopressin as an adjunct to evacuation to reduce blood loss. MTX is more appropriate for patients without urgent indication for surgical intervention. Vasopressin may be used in addition to MTX or as an alternative to MTX for cervical pregnancy with a small gestational sac. Vasopressin may be injected into the cervical stroma, using a 1.5-in, 21- to-22-gauge needle. Other devascularization techniques that reduce the risk of massive bleeding include cervical cerclage, transvaginal suture ligation of the cervical branches of the uterine artery, or cervical stay sutures.

Medical therapy to reduce blood loss should be followed by vacuum aspiration; cervical dilation is often not needed and should

be avoided if possible. Evacuation should be performed soon after embolization, before development of collateral blood flow, ideally in 24-72 hours, though intervals up to 1 week have been reported. Successful treatment of cervical pregnancy with D&C+UAE in the 2021 Fowler review was high (46/53, 87%).

Two small case series involving seven patients utilized small-caliber hysteroscopy as the sole treatment for cervical pregnancy, without need for transfusion or additional intervention. Injected vasoconstrictors, fibrin glue, or bipolar coagulation were used at the implantation site to obtain hemostasis. All patients were 7 weeks gestation or earlier; all but one patient had an initial hCG under 10 000 IU/dL.

For small cervical pregnancies in patients who wish to avoid surgery, uterine artery embolization or systemic MTX injections may be used as primary therapy. In the Fowler review, UAE as initial treatment had a high success rate in a limited number of cases (14/16, 87%). With MTX therapy alone, nearly half of viable cervical pregnancies will require an additional intervention to completely resolve the pregnancy. In the Fowler review, compared with MTX alone, other treatment methods had an increased likelihood of initial treatment success, including D&C with UAE, MTX with UAE, and D&C alone. Due to higher failure rates, we do not recommend primary systemic MTX treatment of cervical pregnancy for patients with serum hCG levels of 10 000 mIU/mL or greater, gestational age of 9 weeks or later, presence of fetal heartbeat, or fetal crown-rump length of >10 mm. The Fowler review found near-complete failure of primary MTX therapy for patients with serum hCG levels of 19 000 mIU/mL or greater (unpublished data). A small case series of three patients who failed treatment with MTX were successfully treated with embryo reduction via cardiac puncture under ultrasound guidance. For either embolization or MTX without a planned evacuation, we recommend follow-up with both serum hCG levels and ultrasound exams with color Doppler flow to follow resolution of the vascular mass.

For those patients with cervical ectopic who have completed childbearing or who have other uterine conditions for which hysterectomy may be curative (eg, large symptomatic fibroids or

adenomyosis), a hysterectomy, including a vaginal approach by a skilled surgeon, is reasonable to avoid the risk of emergency surgery and blood transfusion. Hysterectomy may be the only feasible approach for cervical pregnancy in the second or third trimester or for those who present with intractable hemorrhage.

We do not recommend proceeding with curettage without a preoperative approach to control hemostasis, as the need for hysterectomy may approach 40% for curettage alone.

Despite preoperative measures to reduce the cervical blood supply, the possibility of significant bleeding remains. The Fowler review found an overall transfusion rate of 25%; compared with patients receiving MTX, patients who received D&C or potassium chloride (KCl) as their only intervention had an increased risk of transfusion. Transfusion risk is also higher for patients with an initial hCG over 5000 mIU/mL. Intracervical compression is the first line to control postcurettage bleeding such as use of a 26-Fr Foley catheter with a 30-mL balloon left inflated for 0.5-6 days or use of a double-balloon catheter. After Foley balloon inflation, consider placement of a purse string suture around the external os to prevent expulsion. Tight cervical packing with gauze may be the only option available in low-resource settings. If uterine artery embolization is not performed prior to surgery, it may be used in cases of persistent bleeding if readily available; otherwise, hysterectomy may be indicated.

# ABDOMINAL PREGNANCY

Abdominal pregnancy is a rare form of ectopic pregnancy (1%) where the pregnancy implants in the peritoneal cavity. The incidence is 1:10 000 deliveries. The mortality rate for abdominal ectopic pregnancy is more than seven times that for other ectopic pregnancies and more than 90 times that for intrauterine pregnancy. Perinatal mortality is also high, up to 25%. Early diagnosis and treatment are thus critical. The literature for this rare pregnancy location consists of case reports and small case series. A systematic review of abdominal ectopic pregnancies under 20 weeks of gestation (“early”) found 225 cases from 1965 to 2009 with a maternal mortality rate of 3%. A similar review of pregnancies at 20

weeks or later (“advanced”) from 1965 to 2012 resulted in 31 cases with a maternal mortality rate over 22%.

Risk factors are similar to other ectopic pregnancies, with the exception of IUD use. In the systematic review of early abdominal pregnancies, an IUD was present in 8%.

Abdominal ectopic pregnancy can be diagnosed on ultrasound with findings of an empty uterine cavity and an extrauterine gestational sac. In later gestations, malpresentation, anomalies, and oligohydramnios should prompt suspicion of this condition. Magnetic resonance imaging can aid in localizing the placenta and vascular connections to intra-abdominal structures, which can be helpful in surgical planning. Common placenta implantation sites include peritoneal surfaces, uterus and adnexa, omentum, bowel, liver, and abdominal wall. Preoperative considerations to minimize risk of hemorrhage and injury to other organs include surgeon experience, readily available blood products, angiographic embolization, ureteral catheterization, and bowel preparation.

Management of an abdominal pregnancy is usually surgical as women often present with intra-abdominal bleeding; 25% may require a blood transfusion. At earlier gestations, laparoscopy is preferred over laparotomy for shorter operative time, lower blood loss, and shorter length of stay; laparotomy is the only option in advanced gestations. Even with early diagnosis and laparoscopic management, massive hemorrhage can occur. As with surgical management of other ectopic pregnancy locations, vasopressin may aid in minimizing blood loss. Because vasoconstriction could lead to necrosis, vasopressin should not be injected into the intestinal wall. If an abdominal pregnancy is diagnosed before bleeding, medical management with KCl or MTX is possible, although failure rates approach 50%. Predictors of success of medical management are not yet evident.

In the systematic review of advanced abdominal pregnancy, most were diagnosed at the time of delivery or delivery followed soon after diagnosis; seven cases were expectantly managed. Cases were diagnosed at an average of 30 weeks and delivered at 33 weeks. Congenital malformations and contractures were reported, but most neonates delivered after viability survived (89%).

There is no consensus about whether the placenta should be left *in situ* or removed but both options carry risks. As the placenta is not intrauterine, one cannot rely on uterine contraction to stem bleeding after placenta removal. In a review of advanced abdominal pregnancies (Hymel, 2015), the placenta was commonly left in place, often with coadministration of oral MTX. While leaving the placenta *in situ* can avoid massive hemorrhage, it can result in infection or abscess formation in nearly 67% of patients, more commonly after administration of MTX. Placenta necrosis occurs after MTX administration and can serve as a nidus for infection. If MTX is given after 28 weeks, it may no longer be effective, given the decrease of placental cell mitotic activity. In situ placentas may need surgical re-exploration or result in thromboembolism and death. Researchers have also described pre- and postoperative selective arterial embolization with gelatin sponge pledgets to diminish placental blood flow in advanced abdominal pregnancies before and after fetal removal, with interval placental removal.

# RUDIMENTARY HORN PREGNANCY

A true cornual pregnancy is one in the rudimentary horn of a unicornuate uterus and is a rare variant of ectopic pregnancy. The prevalence of a unicornuate uterus in the general population is 0.1%. The rudimentary horn may communicate with the endometrial cavity; however, more commonly (70%-90%), the horn has not fused to the unicornuate uterus, leading to a noncommunicating horn. Implantation of a pregnancy may occur in either cavity, with varying obstetrical outcomes.

The reported incidence of rudimentary horn pregnancy ranges from 1:76 000 to 1:150 000 pregnancies. An early diagnosis is critical to prevent the morbidity and risk of mortality from uterine rupture due to the thinner than normal myometrium in rudimentary horns. Despite advances in ultrasound, half of rudimentary horn pregnancy cases are diagnosed after uterine rupture in the second or third trimester. Rupture occurs by the second or third trimester in nearly 80%-90% of cases. If these pregnancies continue, they have the added risks of growth restriction, placenta accreta and percreta, and fetal demise.

Ultrasound diagnostic criteria include the following:

- Asymmetrical bicornuate-appearing uterus
- Absence of an intrauterine pregnancy
- Visualization of a gestational sac, mobile and separate from the uterus
- Lack of visual continuity between the cervical canal and the lumen of the pregnant horn
- Gestational sac located eccentrically and 1 cm from the most lateral wall of the uterine cavity
- A thin (<5 mm) myometrial layer surrounding the gestational sac
- Hypervascularization typical of placenta accreta

Suspicion of rudimentary horn pregnancy should trigger further evaluation with either 3D ultrasound or magnetic resonance imaging. This further testing can both confirm the diagnosis and delineate internal and external uterine structures, which is useful for preoperative planning. Imaging can determine whether the rudimentary horn is attached to the unicornuate uterus with a broad and vascular or narrow and fibrous band.

Traditional management of rudimentary horn pregnancy has been resection of the pregnant horn and ipsilateral fallopian tube by laparotomy. The pregnant horn may be separated with electrosurgery, the myometrial defect closed with suture or endo stapler, and the pregnant horn removed through either morcellation or a vaginal incision. Increasingly, as with interstitial pregnancies, laparoscopic approaches are utilized with consideration given to cornuostomy instead of cornual resection. The goal of conservative surgical treatment is to remove the gestational sac without damaging the myometrium, while preventing significant blood loss. The myometrium may be reconstructed with suture, either a square suture (carried through the posterior and anterior cornual walls and then carried back through the anterior and posterior wall at a point 2 cm lateral to the initial knot tied intracorporeally) or an encircling suture (placed around the base of the cornual ectopic to act like a tourniquet). The myometrium may also be closed with an endoloop device, automatic staplers, or an endo stapler.

There are no data comparing the fertility outcomes of women who undergo cornuostomy vs resection of a rudimentary horn. Case reports of conservative management of rudimentary horn pregnancy—including preservation of the ipsilateral tube after removal of the rudimentary nongravid horn and treatment of rudimentary horn pregnancy with MTX without horn excision—report recurrence of tubal or rudimentary horn pregnancy in the subsequent pregnancy.

# HETEROTOPIC PREGNANCY

The risk of heterotopic pregnancy—where an ectopic gestation accompanies an intrauterine gestation—is 1:30 000 pregnancies and is as high as one in 100 pregnancies resulting from in vitro fertilization. While risk factors for heterotopic pregnancy are similar to those for any ectopic gestation, ART-related risk factors unique to heterotopic pregnancy are ovarian hyperstimulation syndrome and multiple embryo transfer. Diagnosis may be delayed by lack of symptoms (thus lack of suspicion) and misdiagnosis of the ectopic gestation as a corpus luteum cyst. Visualization of an intrauterine pregnancy may lead to less careful examination of the other pelvic structures. Consequently, heterotopic pregnancies are generally diagnosed after clinical signs develop, risking increased hemorrhage-related morbidity and mortality.

Shared decision-making is vital when planning treatment of a heterotopic pregnancy. Patients with a desired viable intrauterine pregnancy must be counseled about the risks and benefits of either terminating both pregnancies, or attempting to treat only the ectopic gestation. With the latter approach, there may be more health risks and, in the end, loss of both pregnancies. Regardless of the surgical approach, risk to the intrauterine pregnancy remains; a large case series reported a 31% loss rate. Conversely, if the intrauterine pregnancy is undesired or nonviable, management of this pregnancy can be performed concurrently with a procedure for the ectopic pregnancy.

Most heterotopic pregnancies consist of a tubal gestation combined with an intrauterine pregnancy (**FIG. 20.12**). The recommended approach is laparoscopic salpingectomy. During the

laparoscopic procedure, gauze held by ring forceps can be used vaginally in lieu of a transcervical uterine manipulator. Salpingostomy is not recommended, as hCG levels cannot be reliably followed postoperatively.

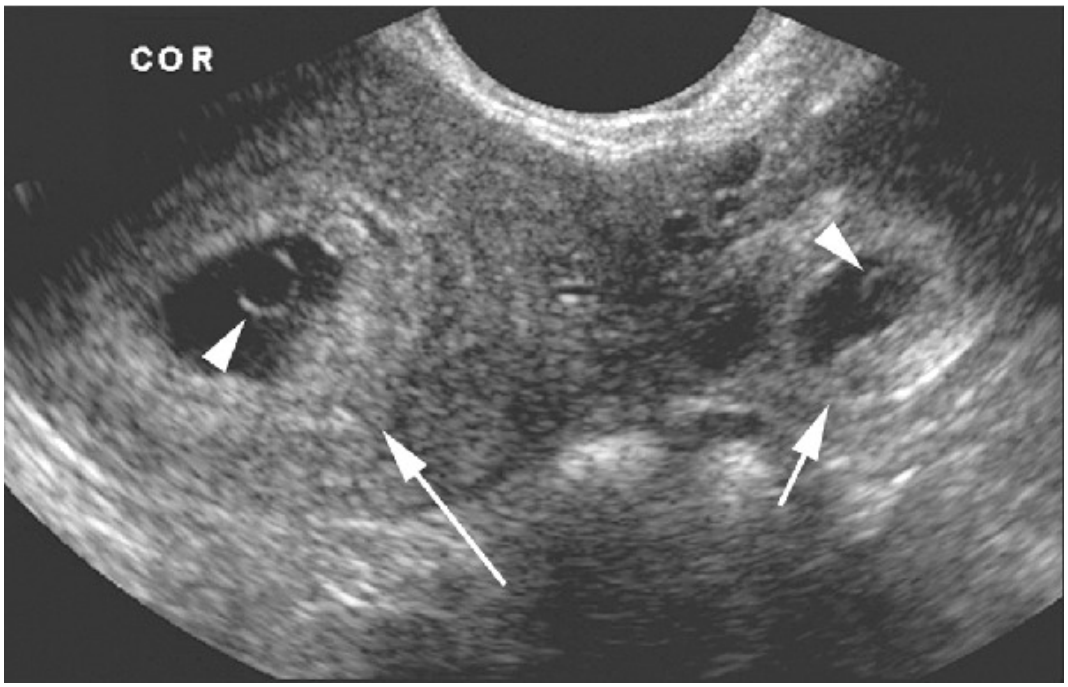


**FIGURE 20.12** Ultrasound image of a heterotopic pregnancy. Coronal transvaginal view through the uterus and left adnexa demonstrates two gestational sacs, one ectopically located in the left adnexa (*short arrow*) and one within the uterus (*long arrow*). This image shows yolk sacs (*arrowheads*) in both the intrauterine and the ectopic gestational sacs. (Reprinted with permission from Doubilet PM, Benson CB. *Atlas of Ultrasound in Obstetrics and Gynecology*. 2nd

ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2011. Figure 29.6.1A.)

For the 10% of heterotopic pregnancies where the ectopic pregnancy is not tubal, management is more complex, treatment experience is limited to case reports or series, and little consensus exists although minimally invasive surgical management is generally preferred. Vetter and colleagues present a case treated with an open resection of a cesarean scar pregnancy. Laparoscopic resection has been reported, with continuation of the intrauterine pregnancy; this case was complicated by difficult visualization of the scar pregnancy and significant bleeding from the vascular bed after removal. Risks with any excision range from removal of too little tissue and persistence of the ectopic pregnancy to a too-deep excision that enters the uterine cavity and threatens the viability of the intrauterine pregnancy. For similar reasons, hysteroscopy and vacuum aspiration are contraindicated if the goal is intrauterine pregnancy preservation. Complications after fetal reduction of the cesarean scar pregnancy with KCl include placenta accreta and massive hemorrhage; additionally, there is an unknown risk of uterine rupture with continued presence of nonviable pregnancy tissue in the lower uterine segment.

There are several reports of open or laparoscopic excisions of interstitial pregnancies with successful continuation of the viable intrauterine gestation. Ovarian heterotopic pregnancies should be managed surgically as recommended for ovarian pregnancies. Tsakos and colleagues presented a review of 44 of heterotopic cervical pregnancies. Management techniques involved multiple mechanisms to control bleeding both before and after a procedure. Removal of the cervical pregnancy was accomplished by various techniques, sometimes in combination. In 13 out of 14 heterotopic cervical pregnancies treated with KCl, the intrauterine pregnancy was preserved. However, in the majority of these cases, severe antenatal and intrapartum hemorrhage were reported, including three hysterectomies. Based on limited data, a heterotopic cervical pregnancy should not be left *in situ* when attempting continuation of

the intrauterine pregnancy. As with abdominal pregnancies, abdominal heterotopic pregnancies can present with hemorrhage and require urgent surgical management. Finally, rudimentary horn heterotopic pregnancies should be managed surgically as recommended for rudimentary horn pregnancies.

For those with relative contraindications to surgery, KCl injection into the sac may be successfully used but retains a risk of toxicity to the other embryo and hemorrhage-related morbidity to the patient. Given the possible negative effects on the remaining pregnancy, systemic MTX and uterine artery embolization are not recommended.

# POSTOPERATIVE CARE

Ectopic pregnancy is a form of early pregnancy loss. The prevalence of psychological sequelae after ectopic pregnancy is higher than is generally realized. More than one-fifth of patients with an ectopic pregnancy will meet criteria for posttraumatic stress or moderate/severe anxiety 1 month after resolution, and nearly 10% will meet criteria for moderate/severe depression. Clinical management and follow-up need to be sensitive to these psychological implications.

Recommendations about return to normal activities should mirror instructions for laparoscopy or laparotomy performed for other indications. Patients with ectopic pregnancies require additional specific posttreatment instructions. They should be counseled to expect bleeding for an average of 2 weeks and return of menses within 8 weeks; those with medically managed ectopic pregnancies may have a less predictable time course for return to menses.

Ectopic pregnancies that are treated surgically can rely on the pathology report to guide further management. If the pathological exam confirms a gestational sac or chorionic villi, no further follow-up is needed, unless the surgeon has reason to suspect that gestational tissue may have been left *in situ*. If no villi are noted on evaluation, an hCG level can be checked in 24-48 hours. Once an initial decline has been confirmed, serum levels can be checked weekly until undetectable.

For patients treated with only nonsurgical management—be it MTX, uterine artery embolization, or other medical approaches—serum hCG follow-up is required. Once the hCG levels are confirmed to be declining appropriately, they can be monitored weekly until undetectable. Patients need to be counseled that ectopic pregnancies can rupture at even low hCG levels, so continued monitoring should be considered an essential part of treatment.

There is no clear guidance on the optimal interpregnancy interval after treatment for ectopic pregnancy. After surgical management of tubal and ovarian ectopic pregnancies, there are no limitations on trying to conceive. Following guidance for patients undergoing myomectomy with significant uterine disruption, after surgical treatment of interstitial ectopic patients should wait 3-6 months before attempting to conceive. Cesarean scar ectopic is likely to recur (up to 40%) and be associated with morbidity. Based on limited evidence, pregnancy should be delayed at least 12 months after treatment of cesarean scar ectopic, with early initial ultrasound and delivery at 34 0/7 and 35 6/7 weeks gestation in facilities equipped to manage hemorrhage. Long acting contraception or, for those who have completed childbearing, permanent contraception should be strongly recommended.

For patients with a previous ectopic pregnancy undergoing ART for a subsequent pregnancy, it may be prudent to transfer a single embryo and use a small transfer media volume (10-20 µL).

# KEY POINTS

- Half of women with an ectopic pregnancy possess no known risk factors; the diagnosis must be considered for all reproductive aged people who present with symptoms and a positive pregnancy test.
- For pregnancies of unknown location, serial serum hCG levels should be monitored to determine the pattern of rise or fall. Once the pregnancy has been deemed nonviable (due to insufficiently rising, plateauing, or falling hCG levels), diagnostic

aspiration or laparoscopy is warranted to determine the location of the pregnancy.

- Vacuum aspiration can expedite the diagnosis of an ectopic pregnancy by confirming the presence or absence of chorionic villi in the uterine cavity. In the setting of absent chorionic villi after aspiration, an ectopic pregnancy is suspected if hCG concentrations do not fall by at least 15% 12-24 hours after the procedure.
- For surgical management of tubal ectopic pregnancy, laparoscopic salpingectomy is often the preferred approach.
- To avoid compromising blood supply to the ovary during salpingectomy, stay close to the fallopian tube during transection of the mesosalpinx.
- Conservative surgical approaches to nontubal ectopic pregnancies are appropriate for hemodynamically stable patients who wish to retain their fertility.
- Nontubal ectopic pregnancies have a high risk of bleeding during removal. Surgeons should consider preventive measures for reduction of the risk of hemorrhage.
- Improved ultrasound technology and criteria allow for earlier diagnosis and more conservative treatment of cesarean scar, interstitial, cervical, and abdominal ectopic pregnancies where delay in diagnosis can result in catastrophic outcomes.
- Management of heterotopic pregnancy mandates consideration of the intrauterine pregnancy.
- Clinical management of ectopic pregnancy should acknowledge that it is a form of early pregnancy loss, and clinical management and follow-up need to address psychological as well as medical needs.

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series of 12 cases. *Aust N Z J Obstet Gynaecol*. 2020;60:130-134.

# CHAPTER 21

# MYOMECTOMY

Linda D. Bradley and Tommaso Falcone

**Classification of Leiomyomas and General Principles of Management**

**Preoperative Investigation**

**Alternatives to Surgical Excision**

**Indications for Surgical Myomectomy**

**Preoperative Optimization**

**General Principles to Decrease Blood Loss at Myomectomy**

**Hysteroscopic Approach to Myomectomy**

Preparation

General Principles of Hysteroscopic Myomectomy

Instrumentation

Operative Approach With Electrosurgical Devices

Operative Hysteroscopy With Vaporization

Hysteroscopic Tissue Retrieval Systems (Morcellators)

Postoperative Recommendations

Complications After Hysteroscopic Myomectomy

**Laparoscopic Myomectomy**

**Robot-Assisted Laparoscopic Myomectomy**

**Myomectomy by Laparotomy**

## Vaginal Myomectomy

Uterine leiomyoma (myoma; fibroids) are benign monoclonal tumors arising from smooth muscle tissue. By 50 years of age, 70% of White women and 80% of African American women will develop at least one uterine leiomyoma. Several risk factors are associated with the prevalence of leiomyoma (TABLE 21.1). Uterine leiomyomata is one of the most common indications for gynecologic surgery, leading to 200 000 hysterectomies and 30 000 myomectomies per year.

### TABLE 21.1
### Characteristics Associated With the Prevalence of Myomas

| | |
|---|---|
| **Race** | African American or Black |
| **Age** | Increasing incidence with age—cumulative incidence of up to 80% |
| **Reproductive history** | Oral hormonal contraceptives/depot medroxyprogesterone acetate (DMPA)*<br>Premenopausal status<br>Increased time since last birth<br>Increasing parity |
| **Genetic factors** | Germ-line mutations associated with fumarate hydratase deficiency; somatic chromosomal rearrangements |
| **Lifestyle** | High body mass index |
| **Medical history** | Hypertension |
| **Family History** | Family history of fibroids |

All risk factors increase prevalence excluding those marked with an *asterisk*, which decreases prevalence.

Severe symptoms develop in about 30% of patients with leiomyomas. The main symptoms associated with leiomyoma are abnormal uterine bleeding, bulk symptoms, pelvic pain or pressure, and urinary symptoms. Emergency department visits for leiomyomas are increasing, especially for symptoms related to abnormal bleeding, suggesting a lack of appropriate management in other settings. Among symptomatic patients, myomectomy results in significant improvement in symptoms and restores health-related quality of life (**TABLE 21.2**). Uterine leiomyomas have also been noted to negatively impact pregnancy outcomes, cause infertility, and lead to recurrent miscarriages. African American women are diagnosed with fibroids at a younger age and with more severe symptoms than Caucasian women. The severity of symptoms at the time of treatment may reflect disparities in care or systemic racism within the health care system.

## TABLE 21.2
## Indications for Myomectomy

- Symptoms that interfere with quality of life
  - Abnormal uterine bleeding
  - Urinary symptoms
  - Pelvic pressure or pelvic pain
- Asymptomatic women with infertility or recurrent pregnancy loss
  - After investigating all other causes
  - Cavity-distorting fibroid
- Previous adverse pregnancy outcome

In a national survey, ~22% of patients responded that uterine leiomyoma interfered with their quality of life all or most of the time and 39% responded that leiomyoma interfered some of the time. Patients also report negative impact on quality of life domains

including body image, sexuality, relationships, and general well-being. Approximately 25% of patients with fibroids miss work and believe that their career potential is impeded. The survey also noted that preservation of the uterus and future fertility was important for 50% of patients.

# CLASSIFICATION OF LEIOMYOMAS AND GENERAL PRINCIPLES OF MANAGEMENT

Uterine leiomyomas are classified based on the International Federation of Gynecology and Obstetrics (FIGO) designation (**FIG. 21.1**). This classification system describes several distinct groups. The first type is totally intracavitary (type 0); the other categories include submucosal leiomyoma with varying intramural components (types 1 and 2), intramural leiomyoma (types 3, 4, and 5), and subserosal leiomyoma (types 6 and 7) with varying intramural components. The classification is important for determining the surgical approach. For example, types 0 and 1 leiomyomas are generally managed hysteroscopically. A type 1 myoma (<50% intramural involvement) can be managed hysteroscopically depending on the size of the myoma. For example, a myoma size >3-5 cm may require preoperative medical therapy to decrease fibroid volume in order to facilitate hysteroscopic intervention. Type 2 submucosal fibroid myomas with more than 50% intramural component require a high level of hysteroscopic skill and are generally approached abdominally. Types 3-7 fibroids should not be approached hysteroscopically.

| | | |
|---|---|---|
| **Submucosal** | 0 | Pedunculated intracavitary |
| | 1 | <50% intramural |
| | 2 | ≥50% intramural |
| **Other** | 3 | Contacts endometrium; 100% intramural |
| | 4 | Intramural |
| | 5 | Subserosal ≥50 intramural |
| | 6 | Subserosal <50 intramural |
| | 7 | Subserosal pedunculated |
| | 8 | Other (specify, eg, cervical, parasitic) |
| **Hybrid Leiomyomas** | 2-5 | Submucosal and subserosal |

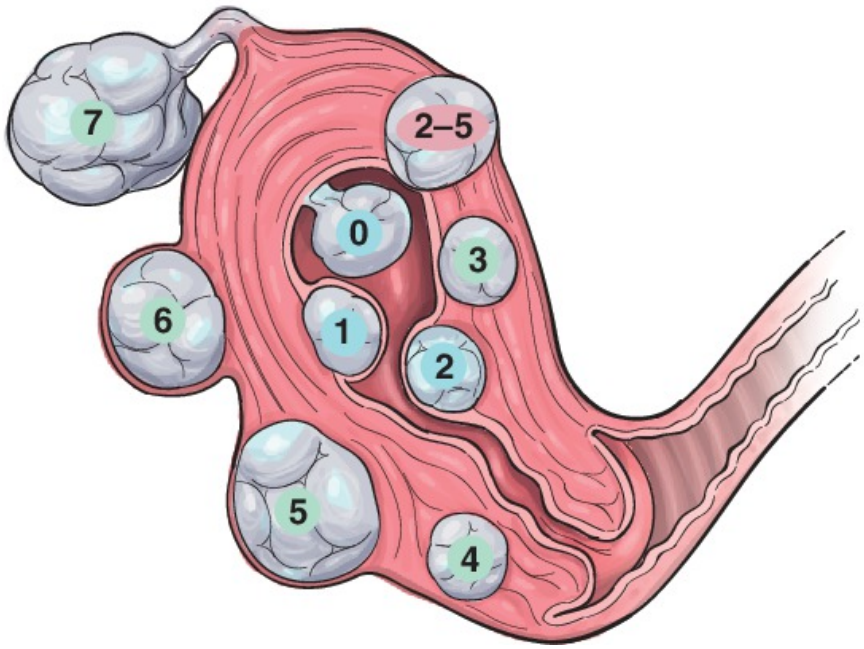



**FIGURE 21.1** International Federation of Gynecology and Obstetrics (FIGO) classification system for uterine fibroids.

## PREOPERATIVE INVESTIGATION

A thorough examination can establish the optimal surgical approach. The presence of leiomyoma is often initially suspected at the time of pelvic examination. If the enlarged uterus is mobile, a minimally invasive approach is preferable. A uterus that is not mobile may suggest other disease such as endometriosis or chronic inflammation, which would make surgery more challenging. Speculum examination may show a prolapsed submucosal fibroid or a cervical leiomyoma, which are managed by different surgical approaches.

Imaging is valuable for further assessment and surgical planning. Ultrasound is considered the gold standard to diagnose uterine leiomyoma as well as to assess location and number. The relationship of leiomyoma to the endometrial cavity is also important for surgical planning; saline ultrasonography can help delineate the penetration of a submucosal myoma into the myometrium and in this way aid in the surgical approach to management. Diagnostic hysteroscopy can be used to appropriately assess the resectability of the lesion.

When numerous fibroids are seen at the time of ultrasonography, magnetic resonance imaging (MRI) may be used for more detail. This modality may be useful to identify and map out leiomyoma before laparoscopic or robotic myomectomy. Furthermore, differentiating a leiomyoma from adenomyosis or an adenomyoma is important for optimal surgical outcome. MRI will sometimes suggest the diagnosis of potential leiomyosarcomas (but this test is not conclusive). MRI can also help determine whether the patient is a candidate for uterine artery embolization (UAE) and specifically to assess the arterial supply to the myomas.

When a patient presents with abnormal uterine bleeding and leiomyoma, it is important to exclude endometrial pathology, such as endometrial cancer or complex endometrial hyperplasia with atypia. An endometrial biopsy should be performed. Anemia is common in patients with heavy menstrual bleeding and should be assessed. Thyroid disease should also be considered, as this can be a cause of heavy menstrual bleeding. Investigation for hematologic causes of heavy menstrual bleeding should always be considered in patients with leiomyoma especially if the menstrual disorder started in

adolescence. Up to 25%-30% of adolescents who present with heavy menstrual bleeding may have an underlying coagulopathy.

The concern that morcellation may lead to the spread of an occult uterine sarcoma at the time of tissue extraction of a presumed uterine leiomyoma has led to an attempt to an increased recognition of the importance of identifying malignant uterine disease before surgery. The U.S. Food and Drug Administration (FDA) notes that occult uterine cancers such as sarcomas are found in ~1 in 225 to 1 in 580 patients who undergo myomectomy or hysterectomy. Leiomyosarcoma is found in ~1 in 495 to 1 in 1100 patients undergoing surgery for myomas.

Unfortunately, even the most diligent preoperative assessment cannot completely exclude the possibility of leiomyosarcoma or other malignancy. It is important to recognize that endometrial adenocarcinoma is the most common malignancy observed in patients with fibroids and abnormal uterine bleeding. Therefore, endometrial sampling is recommended prior to surgery in the setting of abnormal bleeding. Endometrial sampling can also aid in detecting uterine sarcoma. Fibroid size and rate of growth are not predictive: a rapidly growing leiomyoma in a premenopausal patient is not predictive of malignancy, and even masses >20 gestational weeks' size are not associated with increased risk of uterine sarcoma in premenopausal patients. However, these clinical observations are worrisome in perimenopausal and postmenopausal patients. In summary, there are no imaging or laboratory tests such as serum markers or histology from endometrial sampling that can reliably predict a uterine sarcoma.

# ALTERNATIVES TO SURGICAL EXCISION

The main concepts of treatment are shared decision-making and a personalized approach. Short- and long-term goals should be discussed. Expectant management is recommended in asymptomatic patients who are not seeking infertility treatment. Patients can be reassured that leiomyomas typically shrink and

symptoms improve in the postpartum and postmenopausal period. Medical therapy can be used as a long-term treatment or one that is used temporarily until surgical intervention, or as a bridge to menopause. Among patients with leiomyomas, hormonal contraception, including combination oral contraceptives and progestin-only contraceptives, can be used to control abnormal uterine bleeding, as these medications do not cause leiomyomas to grow. Levonorgestrel-releasing intrauterine contraception (eg, Mirena system) can be used in patients with fibroids and a normal uterine cavity to decrease heavy menstrual flow.

The introduction of oral GnRH antagonists such as elagolix or relugolix with estradiol and norethindrone can result in significant reduction in menstrual blood loss. This treatment can be used for up to 2 years. Clinical outcomes are similar to the use of monthly leuprorelin acetate injections. The selective progesterone receptor (SPRM) modulator ulipristal acetate was used by clinicians in Europe and Canada to reduce menstrual bleeding. However, evidence linking this medication with severe liver damage lead to a recommendation from the European Medicines Agency to restrict its use.

Medical treatment can be useful in reversing anemia before surgical intervention. GnRH agonists reduce heavy menstrual bleeding and decrease uterine size, although they are associated with a rapid return of symptoms and uterine size upon cessation of use. Antifibrinolytic agents, such as tranexamic acid, are effective in treating idiopathic regular heavy menstrual bleeding. The response of patients with fibroids and heavy bleeding to tranexamic acid is variable, but this approach can be considered for patients who are not taking an oral contraceptive and for those who do not have a history of embolic disease.

Uterine artery embolization (UAE) is an effective nonsurgical treatment of leiomyoma-associated symptoms such as abnormal bleeding. After UAE, uterine size is typically reduced 30%-45%, with associated improvements in quality of life. Relief of symptoms from UAE occurs in 75%-80%, similar to results following myomectomy. Blood transfusion rates after UAE are very low compared with surgery. However, reintervention is high with UAE, estimated to be

around 17%-31%. In those patients with initial excellent response with UAE, long-term health-related quality of life is similar to patients managed with hysterectomy. Unfortunately, in comparison with myomectomy, UAE has higher reintervention rates, subsequent hysterectomy rates, and complications from the index procedure, such as leucorrhea, expulsion of prolapsing leiomyoma, and intrauterine fistula. Reproductive outcome after UAE is unclear, and the procedure is generally not recommended for patients who desire future fertility. UAE is an excellent option for patients who do not desire future fertility and have medical disorders that increase surgery risk.

Radiofrequency ablation is a technique where heat is delivered directly to the fibroid by transcervical or laparoscopic ultrasound guidance, causing coagulative necrosis. Several clinical trials have shown reduction in fibroid size, symptoms, and improvement in quality of life after radiofrequency ablation. There are limited data on fertility and pregnancy outcomes after treatment.

High-frequency magnetic resonance–guided ultrasound is a thermoablative technique that can be used to ablate fibroids that are easily accessible and if bowel and bladder are not interposed (in which case this approach cannot be used). Leiomyomas >10 cm are difficult to treat with this modality. Contradictions to this approach include the presence of more than four leiomyomas, poor vascularity (nonenhancement with gadolinium), and severe adenomyosis. Leiomyoma size reduction with this method is similar to UAE at about 37%-40%. It is approved for use in patients who desire future fertility. However, the overall reintervention rate at 60 months is as high as 53.9%.

# INDICATIONS FOR SURGICAL MYOMECTOMY

The main indication for surgical myomectomy is to control symptoms that impede quality of life in patients with myomata who desire future fertility. Myomectomy is also a treatment option for patients with no desire for future fertility but wish to keep the uterus. In patients who

have completed childbearing, hysterectomy should be discussed, as this is associated with definitive management of symptoms and no recurrence. Quality of life in all domains improves with both myomectomy and hysterectomy. However, at 1 year after the index surgery, quality of life scores and symptom severity scores are better with hysterectomy. Also, myomectomy is associated with a reintervention rate of at least 15% and subsequent hysterectomy rate of 11%. A recent analysis suggests a reduction over the past 15 years in the utilization of myomectomy for the management of leiomyomas, from 5.5% in 2008 to 2.8% in 2017 for patients over 45 years of age, suggesting that hysterectomy is considered the treatment of choice in this age group. The exception to this general observation would be for a fibroid that is easily managed by operative hysteroscopy.

There is no specific leiomyoma size that requires intervention in patients who are asymptomatic. Surgery is not indicated for prophylactic symptom prevention as there are no reliable predictors of symptom development. Intervention can be considered in asymptomatic patients who desire future fertility and have a submucosal leiomyoma amenable to hysteroscopic surgery. Another potential indication for surgery in asymptomatic patients is the presence of moderate or severe hydronephrosis from ureteral compression.

Surgical intervention is not indicated solely to exclude the possibility of sarcoma. However, in a postmenopausal patient, a rapidly growing uterine mass increases the probability that the mass is malignant. In this situation, myomectomy is not recommended. Referral to a gynecologic oncologist should be considered in such cases.

There is an association of intracavitary or cavity-distorting myomas and infertility or recurrent pregnancy loss. However, it is not clear under which circumstances surgery would improve reproductive outcomes. Surgery can be considered in patients with submucosal or cavity-distorting fibroids after investigating other causes of infertility or recurrent pregnancy loss.

The most minimally invasive surgical approach should be utilized to excise the myomas. This requires an objective assessment of the

size, number, and location of the fibroids. Postoperative morbidity is less with the most minimally invasive approach.

# PREOPERATIVE OPTIMIZATION

A blood type and screen, possible cross match for blood, and urine pregnancy test should be performed before surgery. Prior to surgery, it is important to optimize patient medical conditions, including anemia. For patients with abnormal bleeding, we recommend a complete blood count, possible iron studies, and exclusion of sickle cell or other hemoglobinopathies. Preoperative anemia from chronic blood loss is associated with increased postoperative morbidity and mortality. Correction of anemia without transfusion is the optimal approach. Oral iron supplementation (with vitamin C to enhance absorption) can increase hemoglobin by 2 g/dL within 2-3 weeks if bleeding is controlled. However, oral iron therapy has poor compliance because of gastrointestinal side effects. Furthermore, normal iron stores require up to 6 months of oral therapy, and normal hemoglobin may not be achieved if bleeding is not adequately controlled during this interval. On the other hand, intravenous iron has a therapeutic effect within 7 days, and the peak effect can be achieved if intravenous iron is administered 3-4 weeks before surgery. Intravenous iron has few contraindications but can result in hypersensitivity reaction and iron overload disorders.

In a Cochrane review examining the impact of GnRH agonist treatment before myomectomy, 3-4 months of pretreatment led to a significant improvement in preoperative hemoglobin and hematocrit levels secondary to reduced menstrual bleeding. Volume changes to the fibroid occurred within the first 2 or 3 months. The use of preoperative GnRH agonists resulted in a small (statistically significant but clinically unimportant) reduction in intraoperative blood loss (22-157 mL less than placebo). Moreover, there was no difference in transfusion rate or operating time. Thus, GnRH agonist pretreatment is not recommended solely to decrease interoperative blood loss, but it may be advantageous for correction of preoperative anemia. Preoperative GnRH agonists may decrease uterine size, allowing a surgeon to accomplish an open procedure via a

transverse rather than a vertical incision. A potential disadvantage of GnRH agonists is that they may also decrease the size of the small myomas to a level that may not be observed at myomectomy. Such myomas may then regrow postoperatively, after withdrawal of GnRH suppression. Also, GnRH agonists may cause side effects such as hot flashes and night sweats.

# GENERAL PRINCIPLES TO DECREASE BLOOD LOSS AT MYOMECTOMY

Most clinical trials have shown that laparoscopic surgery decreases blood loss compared with open surgery for similar size leiomyoma. **TABLE 21.3** lists the possible medical interventions that can reduce blood loss at myomectomy. Combinations of these interventions, such as intramyometrial vasopressin plus vaginal or rectal misoprostol, may have an additive effect. The recommendation from a Delphi consensus process suggested that the best approach to decrease blood loss at myomectomy could include (1) the use of tranexamic acid intravenously perioperatively, (2) dilute vasopressin injected into the myoma and myometrium, (3) pericervical tourniquet intraoperatively, and (4) the use of a cell saver in all patients. The additional use of misoprostol, gelatin-thrombin matrix, and vascular clamping may be considered for highest risk patients. A recent review on the use of misoprostol concluded that a single dose of 400 μg (by any route of administration), within 60 minutes prior to incision, reduced blood loss and need for transfusion. Most studies have found no effect on blood loss with the use of oxytocin. Intraoperative blood salvage techniques are also useful if excessive blood loss is expected as it may decrease the necessity for allogeneic blood transfusion.

## TABLE 21.3
## Perioperative Medical Measures to Reduce

## Intraoperative Blood Loss

| AGENT | MEAN DIFFERENCE IN BLOOD LOSS VS PLACEBO | NEED FOR BLOOD TRANSFUSION |
|---|---|---|
| **Intramyometrial vasopressin[b]** | 245 mL | Decreased |
| **Intramyometrial bupivacaine and epinephrine[a]** | 68 mL | No effect |
| **Vaginal misoprostol[b]** | 97 mL | No effect |
| **Vaginal dinoprostone[a]** | 131 mL | Decreased |
| **Gelatin thrombin matrix[a]** | 545 mL | Decreased |
| **Fibrin sealant patch[a]** | 26 mL | No effect |
| **Intravenous ascorbic acid[a]** | 411 mL | No effect |
| **Intravenous tranexamic acid[a]** | 243 mL | No effect |

Not all drugs are available in all countries. Also, some medications are not FDA approved for these indications.

[a]Low-quality evidence.

[b]Moderate-quality evidence.

Data from Kongnyuy E, Wiysonge CS. Interventions to reduce haemorrhage during myomectomy for fibroids. *Cochrane Database Syst Rev*. 2014; (8):CD005355.

The use of mechanical tourniquets to occlude the uterine blood supply at myomectomy has also been shown to decrease blood loss. Tourniquets can be created with either a red rubber catheter tied around the cervix or with placement of a polyglactin suture around the cervix. Both of these approaches, when deployed with the simultaneous use of Satinsky vascular clamps placed bilaterally on the infundibulopelvic ligaments, have been shown to decrease blood transfusions. There is low-quality evidence that a loop ligation of the vessels of the myoma pseudocapsule can decrease blood loss, but this technique has not proven to reduce transfusion rate. Because of the challenge in using tourniquets during a laparoscopic or robot-assisted procedure, vascular clamps that fit through a trocar (eg, Bulldog clamps) can be used to occlude the uterine artery temporarily. A systematic review and meta-analysis suggested that the use of permanent and temporary occlusion of the uterine arteries at their origin decreases blood loss and transfusion rates. However, data on reproductive outcomes are lacking. Therefore, in those

patients who desire future fertility, we recommend that only temporary methods should be utilized.

The use of an ultrasonic device rather than electrosurgery has also been shown to reduce blood loss by 50-60 mL, an amount that may not be clinically significant. The use of unidirectional and bidirectional barbed suture can decrease blood loss at laparoscopic or robotic myomectomy as well as decrease operative time where suturing is more challenging.

# HYSTEROSCOPIC APPROACH TO MYOMECTOMY

Hysteroscopic myomectomy is a minimally invasive transcervical procedure performed under direct visualization for removal of intracavitary and submucosal leiomyomas. This approach provides an alternative to hysterectomy for the treatment of abnormal uterine bleeding owing to endoluminal leiomyomas. Patients with intracavitary and submucous myomata may benefit from hysteroscopic myomectomy in the setting of abnormal uterine bleeding, infertility, experience recurrent pregnancy loss, and suffer from leukorrhea or dysmenorrhea and for those who have failed medical therapy (**BOX 21.1**).

## BOX 21.1 STEPS IN THE PROCEDURE

### Myomectomy—Hysteroscopic Approach

- Detailed review of preoperative imaging on day of surgery before induction of anesthesia.
- Thorough abdominal and bimanual examination to determine uterine size and position.
- Funnel draping with outflow tubing connected to canister for measurement of fluid deficit.

- Ask the anesthesiologist to calculate the mean arterial pressure (MAP) to determine the initial hysteroscopic intrauterine pressure used during the case.
- Set fluid management system alerts to predetermined fluid deficit based on solution used and cardiac pulmonary status of the patient.
- Grasp the cervix with single-tooth tenaculum, and inject dilute solution of vasopressin (20 units = 1 ampule) in 200 mL normal saline in 5-cc aliquots into cervical stroma at 10, 2, 5, and 7 o'clock positions.
- Dilation with Hegar dilators—using half-size dilators if needed to accommodate diameter of operative hysteroscope being used. Do not overdilate.
- Adjust intrauterine pressure of fluid management systems as needed to maintain clarity of visualization. This is often above the MAP to tamponade blood vessels and to clear debris.
- Place the wire loop of the resectoscope behind the leiomyoma.
- Activate the electrode with the foot pedal and move the hysteroscopic loop toward the surgeon.
- Move the electrode in long excursions to cut larger tissue fragments.
- The cut fibroid has a white or whorled appearance, and myometrial fascicles are pink and have longitudinal white grooves. Separate the slender connective bridges that join the fibroid to the adjacent myometrium.
- Intermittently lower and raise the intrauterine pressure in order to help enucleate the leiomyoma.
- Monitor fluid absorption carefully during case. More rapid fluid absorption occurs with type 1 and type 2 leiomyomas and prolonged surgical procedures.
- When visualization is hampered owing to tissue fragments, halt the procedure and remove tissue fragments. Under direct

visualization with the wire loop, slowly retract the hysteroscope and let the fragments tumble out under direct visualization. To further remove tissue fragments, the surgeon may need to remove the hysteroscope and grasp blindly with polyp forceps or Corson graspers. This must be performed carefully to decrease risk of uterine perforation.

- Reinsert the hysteroscope and continue to resect until procedure is completed or maximal fluid deficit occurs.
- Confirm removal of all tissue fragments from the uterine cavity to decrease postoperative leukorrhea, odor, adhesions, and bleeding.

Modern gynecologic surgical practice places increasing reliance on operative hysteroscopy as a minimally invasive technique for the treatment of abnormal uterine bleeding in patients with intracavitary and submucosal leiomyomas. Menstrual bleeding improves with complete removal of lesions. Compared with hysterectomy or other approaches to myomectomy, postoperative recovery is brief, infectious complications are infrequent, patients require nominal postoperative pain medications and narcotics, and there is decreased perioperative morbidity and mortality. The impetus for operative hysteroscopic removal of leiomyomas has been threefold. First, hysteroscopic procedures to treat submucous fibroids have been facilitated by technical advances (see Chapter 15, Hysteroscopy). These advances include the development of smaller caliber rigid operative hysteroscopes with working ancillary channels, bipolar technology, bipolar radiofrequency hysteroscopes, improvements in fluid management systems, high-definition cameras, and emerging use of both resectoscopes and hysteroscopic tissue retrieval systems (HTRS). Second, patient preference for minimally invasive treatment options for leiomyomas has influenced the demand for operative hysteroscopy. Finally, resident training includes operative hysteroscopy as an important surgical tool to be mastered during resident education. Operative hysteroscopy has largely replaced dilation and curettage for the treatment of intracavitary and endocervical lesions, as it offers

continuous visualization, confirms complete removal of intracavitary lesions, and is effective in treating menstrual dysfunction.

# Preparation

Hysteroscopic myomectomy may be a complex procedure, requiring excellent manual dexterity and advanced skills to extricate intracavitary leiomyomas. Determining feasibility of operative hysteroscopy requires thorough preoperative evaluation. Goals are to minimize incomplete resection, regrowth, recurrence, and complications. Most submucous fibroids occur at the corporeal sites but may occur in the cornua, fundal, posterior, anterior, lateral, or endocervical surface and may require unique hysteroscopic techniques and strategies for removal.

The most sensitive diagnostic tests to evaluate the endometrial cavity prior to hysteroscopic myomectomy are diagnostic office hysteroscopy and saline infusion sonography. Alternatively, MRI can be considered in patients with uterine enlargement >12-14 weeks pregnancy or if ultrasound scanning is technically difficult owing to obesity, uterine position, inability to distend the uterine cavity, or multiple uterine leiomyomas. These modalities have an increased sensitivity to determine size, location, number, and depth of myometrial involvement/penetration of intracavitary leiomyoma.

An important determinant of the safety and feasibility of hysteroscopic myomectomy is the “myometrial-free margin.” This can be evaluated via saline infusion sonography or MRI. Although uterine remodeling occurs during operative hysteroscopy, it is important to have at least a 1-cm-thick margin from the lesion to the serosal surface if hysteroscopic resection is planned. Knowing this, the surgeon can gauge the complexity of hysteroscopic myomectomy, the degree of myometrial involvement, and the likelihood of completing the procedure in one setting. In addition, this information assists with surgical planning, including surgical device selected, distension fluid choice, risks of complications, and fluid intravasation. Informed consent for surgical risks and anticipated complications is best achieved with thorough preoperative evaluation.

Although the FIGO classification is the standard nomenclature for communication of fibroid location (**FIG. 21.1**), a number of classification systems have been proposed. The European Society for Gynecological Endoscopy (ESGE) classification system describes only the degree of myometrial penetration of the submucous fibroid. A third system, the European Society of Hysteroscopy (ESH) classification system (**TABLE 21.4**), is intended to reflect the likelihood of a one-step hysteroscopic procedure and a risk for complications based on endometrial cavity protrusion and size of the leiomyoma. Complete resection can be expected in 96%-97% of type 0, 86%-90% of type 1, and 61%-83% of type 2 leiomyomas. Additionally, the amount of fluid absorption can also be predicted by the preoperative degree of myometrial involvement and length of surgery. The upper limit size of the leiomyoma resected will depend on surgeon expertise and how quickly surgery can be performed before reaching maximal fluid absorption.

## TABLE 21.4
## European Society of Hysteroscopy (ESH) Classification for Submucous Myomas

**Classifications**

- Type 0—fibroids reside completely in the endometrial cavity; also called intracavitary leiomyoma
- Type 1—intramural component, but >50% of the fibroid is located within the endometrial cavity
- Type 2—intramural component, but <50% is intracavitary component

A type 0 myoma is totally intracavitary (**FIG. 21.2**) and usually easily removed. However, even some type 0 myomas cannot be removed hysteroscopically, such as those over 7 cm (**FIG. 21.3**). In one prospective study of 122 patients, 90% of those with fibroids ≤3 cm were able to avoid additional fibroid surgery, compared with 60% among those with fibroids ≥4 cm.

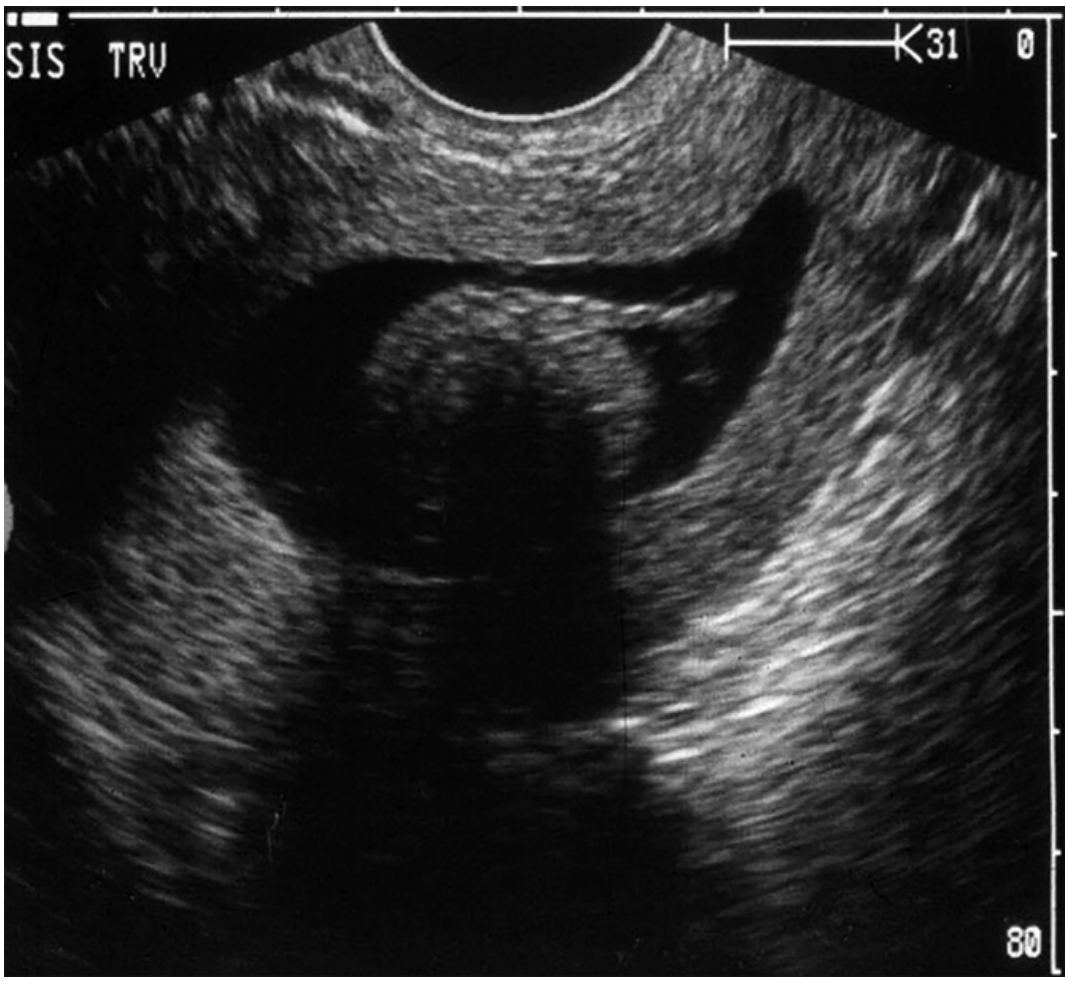



**FIGURE 21.2** Saline infusion sonogram of intracavitary myoma FIGO 0 with necrotic debris attached leiomyoma—this myoma is amenable to hysteroscopic resection.

**FIGURE 21.3** MRI of intracavitary myoma FIGO 0. Notice the uterus is enlarged to the umbilicus. This myoma is not amenable to hysteroscopic resection.

Removal of myomas with deeper myometrial involvement (type 1 or 2) and diameter >3 cm requires advanced hysteroscopic skills. The American Association of Gynecologic Laparoscopists (AAGL) recommends that submucosal fibroids with diameters of 4-5 cm be removed hysteroscopically only by experienced surgeons. Additionally, surgeons may wish to provide informed consent for a

two-staged hysteroscopic myomectomy in patients identified with large fibroids or type 1 and type 2 fibroids ≥4-6 cm. Data demonstrate increased recovery, complications, and incomplete resection in patients with fibroids >3 cm. In such cases, surgeons should consider pharmacologically decreasing the size of the myoma with a GnRH agonist prior to resection. Among women with multiple fibroids, hysteroscopic myomectomy of a submucosal fibroid may be considered in the setting of expectant management of other intramural and subserosal fibroids. An example is a patient with uterine fibroids who does not have bulk symptoms but who has bleeding attributable to intracavitary lesions. Such a patient may benefit from the isolated removal of intracavitary myomas, even if other leiomyomas are present.

# General Principles of Hysteroscopic Myomectomy

Continuous intrauterine distention is required for operative hysteroscopy. Generally, the lowest intrauterine pressure used for hysteroscopy is 75-100 mm Hg; however, higher pressures may be needed when the uterine size exceeds that of a 12- to 14-week pregnancy, when there are multiple intramural fibroids, and if intracavitary fibroids are >4 cm.

During operative hysteroscopy, fluid media used for uterine distention are administered via a continuous fluid management system. For hysteroscopic myomectomy, the ideal fluid management systems offer instantaneous determination of fluid deficit, configurable alarms to alert the surgeon to preset deficit limits, ability to vary intrauterine pressure, technology to facilitate detection of uterine perforation, automatic flow rate adjustment and nonpulsatile flow infusion, and options that minimize surgical interruptions when fluid bags are empty. The amount of fluid absorption depends on length and complexity of surgery. The cardiac, renal, and pulmonary status of the patient must be known and assessed before the operative hysteroscopy. Patients with compromised cardiopulmonary and renal function may tolerate only small volumes of intravascular

fluid absorption. Perioperative consults with an anesthesiologist, nephrologist, pulmonologist, or hematologist may be beneficial in preparing patients with medical comorbidities for surgery.

During hysteroscopic myomectomy, the gynecologist must provide frequent feedback to the anesthesiologist regarding fluid deficit, blood loss, and type of fluid used. The anesthesiologist should inform the surgeon if clinically significant hemodynamic changes occur, including oxygen saturation, end-tidal $CO_2$ levels, lung sounds, vital signs, mean arterial pressure (MAP), and cardiac arrhythmias. The procedure should be halted until hemodynamic changes resolve and a determination is made whether surgery should proceed.

Blood loss is usually minimal during hysteroscopic myomectomy. While informed consent for blood transfusion should be obtained, it is rarely needed in patients who do not have preoperative symptomatic anemia.

In reproductive-aged women, hysteroscopic myomectomy is typically timed with the menstrual cycle. Timing must be individualized. Surgery during the early proliferative phase may be easier owing to thinner endometrium and less tissue debris and blood compared with surgery during the secretory phase. In contrast, patients with prolonged anovulatory cycles may have copious, fragile, exaggerated, proliferative endometrium that bleeds easily during operative hysteroscopy. In such cases, hysteroscopic resection may create abundant tissue debris, leading to unsatisfactory visualization that requires the use of more hysteroscopic fluid and increasing the length of the myomectomy procedure. Therefore, patients with anovulatory menses may benefit from a course of preoperative progesterone therapy to luteinize the endometrium. Once the progesterone therapy is withdrawn, the patient will have menses, and surgery can then be performed. In addition, some patients with ovulatory and heavy menses owing to submucosal fibroids bleed frequently, making it difficult or impossible to schedule surgery in the early proliferative phase. In general, surgery should not be canceled because of bleeding.

Cervical preparation for operative hysteroscopy is reviewed in Chapter 15. We consider administration of misoprostol in patients

with anticipated cervical stenosis. Myometrial contractions may facilitate migration of leiomyomas from an intramural to intracavitary location, facilitating complete removal. Because misoprostol softens the cervix, cervical dilation may be easier, and the risk of uterine perforation and cervical lacerations thereby decreased. Tolerable side effects of preoperative misoprostol include pyrexia, nausea, bloating, cramping, and diarrhea, all self-limited. Acetaminophen or nonsteroidal anti-inflammatory drugs can be used to manage symptoms.

Diluted vasopressin is useful when performing hysteroscopic myomectomy owing to the decreased risk of hysteroscopic fluid absorption, facilitation of cervical dilation, and decreased uterine bleeding. Twenty units of vasopressin (1 ampule) is mixed in 200 mL normal saline and injected into the cervical stroma in 5-mL aliquots (1 cm depth) at the 10, 2, 5, and 7 o'clock positions. Avoid injecting at the 3 o'clock and 9 o'clock positions to reduce the potential for vascular injection. Hemodynamic and cardiac stability must be confirmed with the anesthesiologist before intracervical injection. The vasopressin should be aspirated and injected slowly (over 2-3 minutes) into the cervical stroma. If blood is aspirated, injection should not be made in that position. Rather the syringe should be removed and another intracervical stromal location attempted. Vital signs should be monitored closely for bradycardia, cardiac arrhythmias, and hypertension. Because vasopressin lasts about 20-30 minutes, if surgery is prolonged or bleeding increases, additional vasopressin may be required.

# Instrumentation

Instrumentation for hysteroscopic myomectomy is reviewed in Chapter 15. Hysteroscopic myomectomy can be performed with an operative resectoscope or a HTRS. Both resectoscopes and HTRS rely on continuous visualization of intracavitary lesions, while removing the pathologic tissue under direct control.

With either technique, use of a fluid management system is important for patient safety, enhances surgical technique, and improves patient outcome. The ability to vary intrauterine pressure

above and below the MAP facilitates complete fibroid excision. At the beginning of the surgery, the anesthesiologist can calculate the MAP to determine the initial hysteroscopic intrauterine pressure. Varying the intrauterine pressure during the procedure decreases the risk of encountering a false-negative view of the uterine cavity. With high pressure, a fibroid may be compressed into the myometrium, creating a "sinking fibroid." This may reduce the likelihood that the fibroid is recognized and excised, leading to the perception of recurrence. When bleeding obscures the surgical site, a temporary increase in intrauterine pressure will tamponade the endometrial/myometrial arterioles.

At the beginning of hysteroscopic myomectomy, the surgical team should set the fluid management system to a predetermined fluid deficit, based on the solution used and medical history. In addition to an adherent perineal funnel drape (as described in Chapter 15), we recommend using a PuddleVac, which is a single-use disposable floor aspirator that quickly removes fluid from the operating room floor can be moved manually with a push handle to anywhere hysteroscopic fluid accumulates. It can collect an average of 700 mL of fluid per minute and increases the accuracy of fluid-deficit calculations.

## Operative Approach With Electrosurgical Devices

In 1976, Neuwirth and Amin used a urologic resectoscope and a monopolar loop to perform the first hysteroscopic myomectomy. In contemporary practice, many surgical manufacturing companies provide operative hysteroscopic devices (**FIG. 21.4**). As described in Chapter 15, electrosurgical devices have several components (**FIG. 21.5**), including an outer sheath that surrounds recirculating fluid channels for the telescope. Operative hysteroscopy can be performed with a 0-degree telescope or with a slightly forward-oblique 12- to 30-degree telescope. There are telescopes with an outer diameter of 3-4 mm, and internal and external sheaths ranging in size from 13 to 31 Fr. The size of the wire loop determines the

amount of tissue fragment (“chips”) that can be resected with each passage of the loop through the fibroid.

**FIGURE 21.4** Bipolar generator with bipolar hysteroscopes, in three sizes (15 Fr, 22 Fr, and 24 Fr). (© KARL STORZ SE & Co. KG, Germany.)

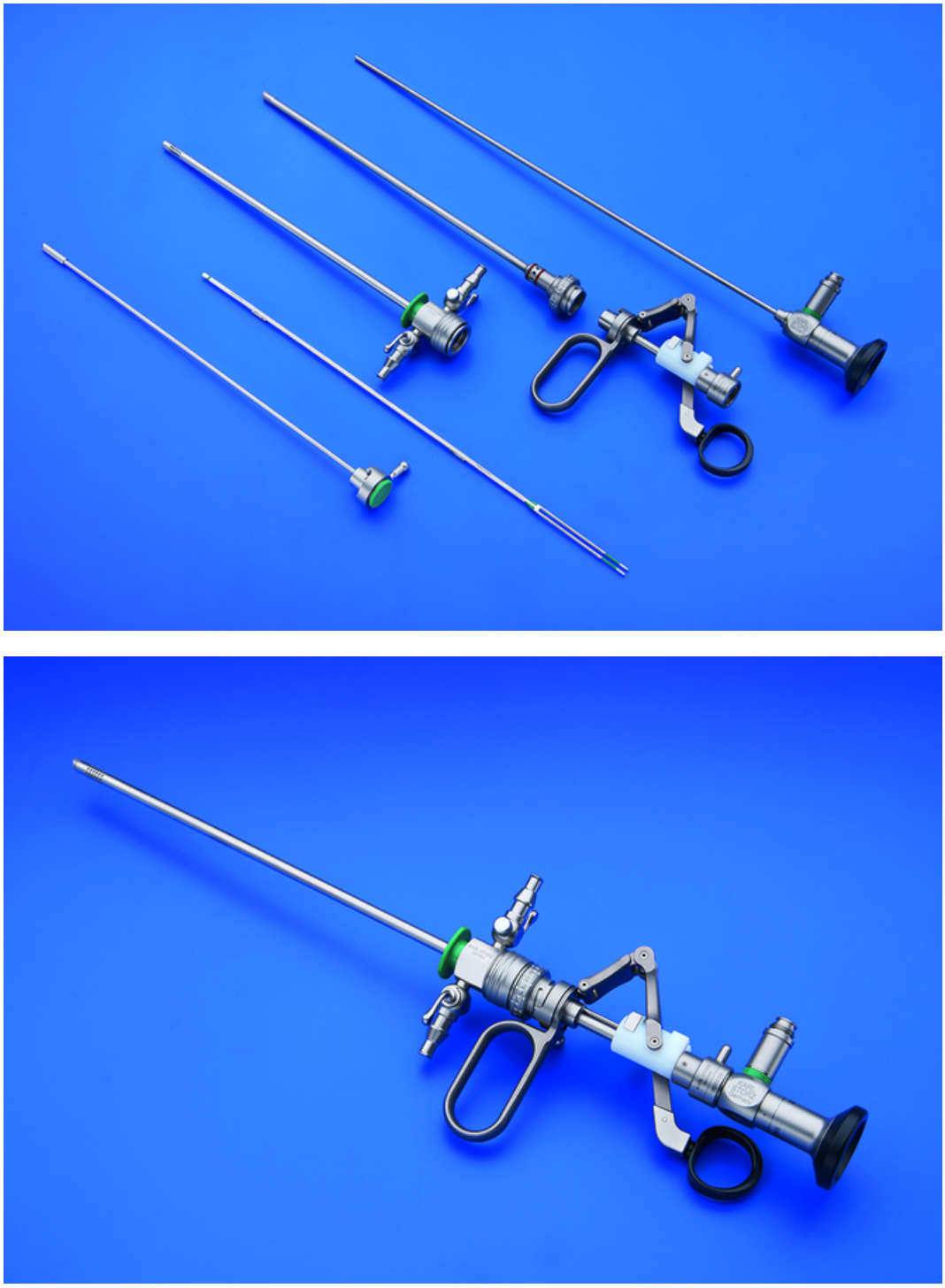


**FIGURE 21.5 Left panel.** Standard hysteroscopic instrument—obturator, wire loop, outer sheath, inner sheath, working element, and lens. **Right panel.** Assembled

bipolar resectoscope. (© KARL STORZ SE & Co. KG, Germany.)

Operative resectoscopes contain a working element through which wire thermal loops, cutting knife, cold loops, and vaporizing electrodes (including balls and barrels) can be attached. These instruments include a channel for inflow of distention medium and an outflow channel for the removal of bloody fluid and tissue debris, providing continuous and clear visualization of the endometrial cavity. Further, an element connects the instrument to the electrosurgical generator to activate electrical energy, with a foot pedal to control cutting and tissue coagulation.

The hysteroscopic “slicing” resection technique requires repeated and progressive passages of the activated wire loop that maintains contact with the fibroid (**FIG. 21.6**). The wire loop should be placed behind the lesion and the loop activated by the foot pedal. Moving the loop from cephalad to caudad permits continuous visualization of the wire loop and decreases the risk of uterine perforation. Adequate distention of the uterine cavity is necessary when the hysteroscope is being advanced and when tissue is being resected. Care must be taken when resecting lesions at the fundus, near a cesarean scar, and near the tubal ostia—as these regions are the thinnest within the uterine cavity.

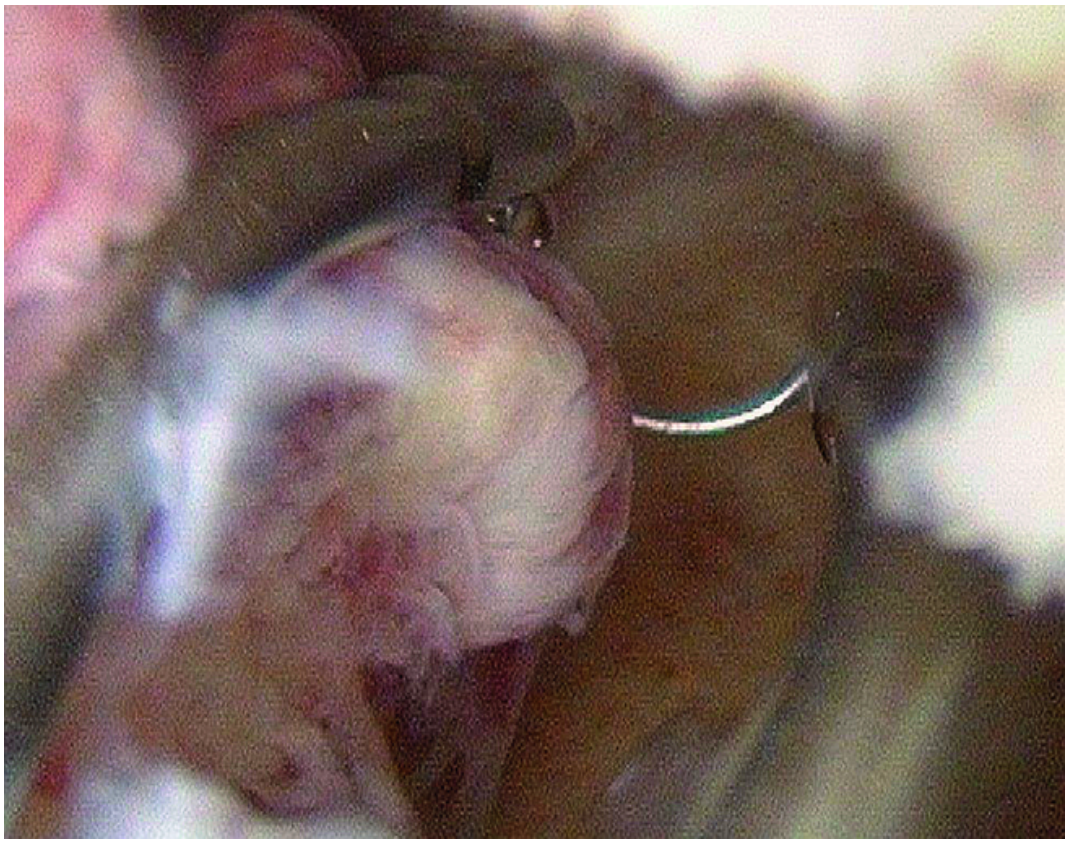
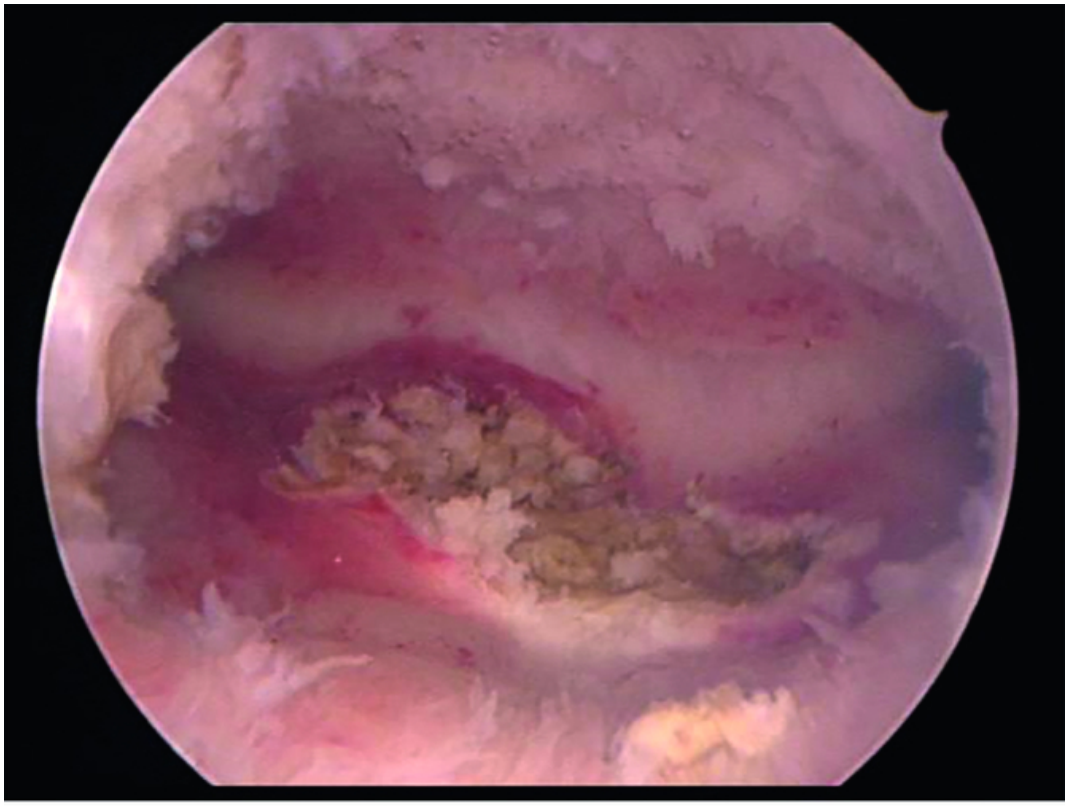


**FIGURE 21.6** Loop resection of fibroid with proper loop placement behind the fibroid and activated as the loop is pulled. This is a bipolar loop.

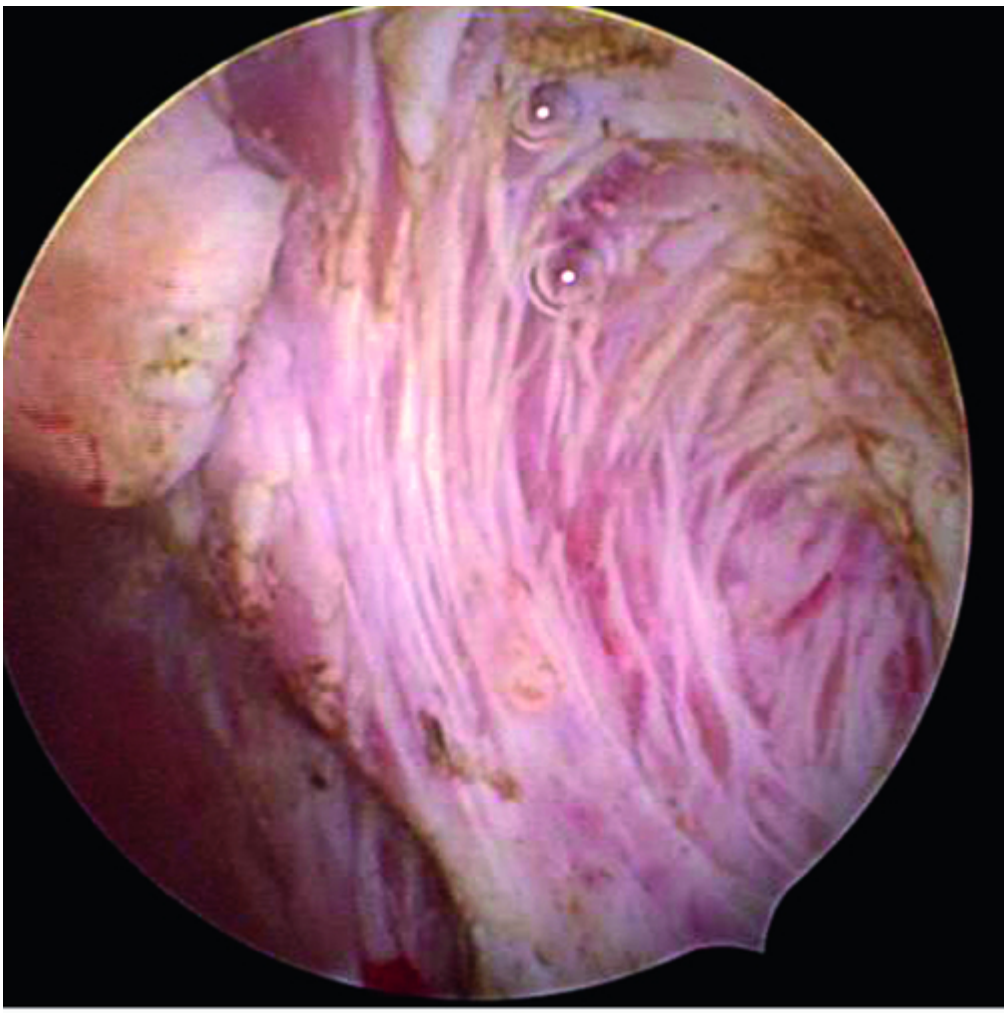
An advantage of bipolar (vs unipolar) loops is that the electrical current can be activated without tissue contact. Additionally, tissue adherence to the wire loop is reduced with a bipolar wire loop. After the fibroid is cut, tissue fragments will accumulate and float within the uterine cavity. In general, resection continues until tissue fragments begin to obscure the view. The tissue fragments can be retrieved under direct visualization with the wire loop or blindly with a polyp or uterine forceps or irrigated out under direct visualization through the endocervical canal into the vagina and collected. The preferred technique is to remove tissue fragments under direct visualization with the wire loop and allow fragments to fall out of the

cervix while slowly removing the hysteroscope. This latter technique decreases the risk of uterine perforation as the tissue fragments are removed under direct visualization.

The surgeon should continue to slice the leiomyoma until the pink fasciculate myometrial fibers are noted and the whorled appearance of the fibroid is absent (**FIG. 21.7**). This can be achieved by separating the slender connective tissue that bridges the fibroid to the adjacent myometrium. The use of electric energy should be minimized when the pink fascicles are seen to prevent further resection of myometrial tissue, as this would increase fluid absorption, bleeding, and uterine perforation. All tissue fragments should be sent to pathology for histologic evaluation and to be weighed. If tissue fragments are retained in the uterus, the patient may experience leukorrhea, colicky pain, intrauterine infection, odor, prolonged serosanguineous discharge, and chronic endometritis. Incomplete resection may result in persistent symptoms.



**A**



B

**FIGURE 21.7** **A.** Posthysteroscopic resection view of complete fibroid removal from posterior uterine wall. **B.** Close-up view after complete resection—the resection is considered complete because the myometrial fasciculate fibers are seen.

Another useful hysteroscopic “slicing” technique requires that the surgeon divide the type 0 fibroid into two half-spheres and then each half is sliced from the free edge to the base into two to three fragments and retrieved through the cervix with grasping forceps.

Care must be taken to prevent uterine perforation because this is performed blindly.

Several techniques have been described to approach resectoscopic retrieval of type 1 and type 2 fibroids, which have myometrial penetrance. The main objective is to separate the fibroid from its pseudocapsule; intermittent uterine decompression allows progressive protrusion of the intramural component into the cavity. Progressive resection can then occur. This is preferred to resection within the myometrium. The surgeon may also consider removing all instruments and waiting 5-10 minutes for myometrial contractions to facilitate fibroid migration into an intracavitary location, facilitating complete removal.

To encourage the protrusion of the intramural component of a type 1 or type 2 myoma, a technique of “hydromassage” can be used. This requires an automatic fluid management system with rapid change in intrauterine pressure. This is achieved via stopping and starting the fluid as well as periodically removing the hysteroscope from the endometrial cavity. This technique increases myometrial contractions and facilitates migration of the intramural component into the uterine cavity. In patients with a particularly large myoma with large cavity, a “manual massage” can sometimes be performed by placing a finger into the uterus (like obstetric maneuvers as Crede’s) and massaging the endocavity to help expel the fibroid into the uterine cavity.

Resection of a type 2 leiomyoma may leave a volumetrically significant portion of the leiomyoma retained within the myometrium, with the potential for a staged procedure. If the remaining portion is more intramyometrial than intracavitary, further attempts of a second-stage hysteroscopic resection may be incomplete. Therefore, postoperative evaluation with saline infusion sonogram or magnetic resonance imaging is recommended (eg, prior to attempting a second hysteroscopic procedure) to confirm the size and relative location of the remaining fibroid. Informed consent should reflect the possibility of incomplete excision and the need for additional procedures in some cases.

Deeper lesions (type 1 and type 2 leiomyomas) may benefit from resection technology. However, the learning curve may be longer for

operative resectoscopy vs HTRS. Increased surgical volume and the use of training simulators are expected to improve surgical acumen, allowing the surgeon to approach retrieval of larger leiomyomas and complete the procedure with either device. Fluid management with monopolar hysteroscopic myomectomy is especially critical. As noted, this technique requires nonionic fluid media such as 1.5% glycine, 3% sorbitol, or 5% mannitol. The risk of hyponatremia increases with increasing fluid deficit. With these hypoosmolar fluid media, many surgeons feel uncomfortable continuing the procedure with a fluid deficit >750 mL. However, if interoperative serum electrolytes are normal, surgery can proceed until the fluid deficit reaches 1500 mL. Surgery should be stopped at a deficit of 1500 mL due to the risk of a precipitous drop in serum sodium. The length of surgery as well as depth of penetration of the leiomyoma will determine the amount of fluid absorption. Therefore, larger leiomyomas may not be fully excised before this limit is reached, increasing the probability of incomplete resection and persistence of symptoms (**BOX 21.1**).

## Operative Hysteroscopy With Vaporization

Vaporization of fibroids may be performed with spherical or cylindrical electrodes that are dragged along the surface of the leiomyoma. Bipolar and monopolar hysteroscopic devices also have electrosurgical vaporizing balls and barrels that vaporize myomas without tissue analysis. They may be spherical or cylindrical or have a multidentate surface. This design functions like an array of electrodes, and when used on high cutting energy, vaporizes tissue quickly without generating tissue fragments. In most cases, the hysteroscope does not need to be removed and reinserted. The current should be applied when the electrode is in contact with the tissue, and the electrode should be moved slowly and in the direction of the operator. The degree of vaporization depends on contact with the fibroid, wattage, duration of contact, and resistance (tissue debris on the electrode). A low-voltage current with high power is used. The

entire fibroid should not be vaporized because as there would be no histologic specimen. While the risk of leiomyosarcoma and borderline lesions are rare, microscopic evaluation is imperative. Therefore, once vaporization has decreased the size of the lesion to where it can be removed with the wire loop, the vaporizing electrode should be removed and replaced with the wire loop to complete the procedure and submit to pathology for microscopic examination.

The use of high-powered vaporizing electrodes is associated with the production of numerous gas bubbles. These may obscure the view but also enter the vascular system. The bubbles dissipate quickly as long as the rate of formation does not exceed the rate of dissipation. In this setting, it is important that the anesthesiologist continuously monitor the end-tidal $CO_2$.

## Hysteroscopic Tissue Retrieval Systems (Morcellators)

Hysteroscopic tissue retrieval systems (HTRS) use mechanical methods to excise and aspirate tissue (see Chapter 15, FIG. 15.8). These systems are associated with production of fewer tissue fragments, fewer insertions of the hysteroscope, and the use of saline as the distention media. For patients with risk factors for uterine perforation (eg, cervical stenosis, markedly retroverted/retroflexed uterus, menopausal status, and small uterine cavities), tissue retrieval systems have additional theoretic advantages. Tissue retrieval systems also permit visually directed dilation and curettage of the endometrial cavity.

The mechanical aperture of the HTRS is side cutting and shallow, thus minimizing the risk of perforation (**FIG. 21.8**). Two commercially available devices do not use thermal energy. One uses radiofrequency energy to coagulate. Currently, HTRS use two metal, rigid, hollow devices that provide removal of tissue debris. They also include an ancillary channel through which a disposable HTRS is placed to mechanically cut and retrieve tissue. The outer sheath ranges in diameter from 5 to 9 mm. They both use saline as the

distending medium and should be used with a fluid management system.

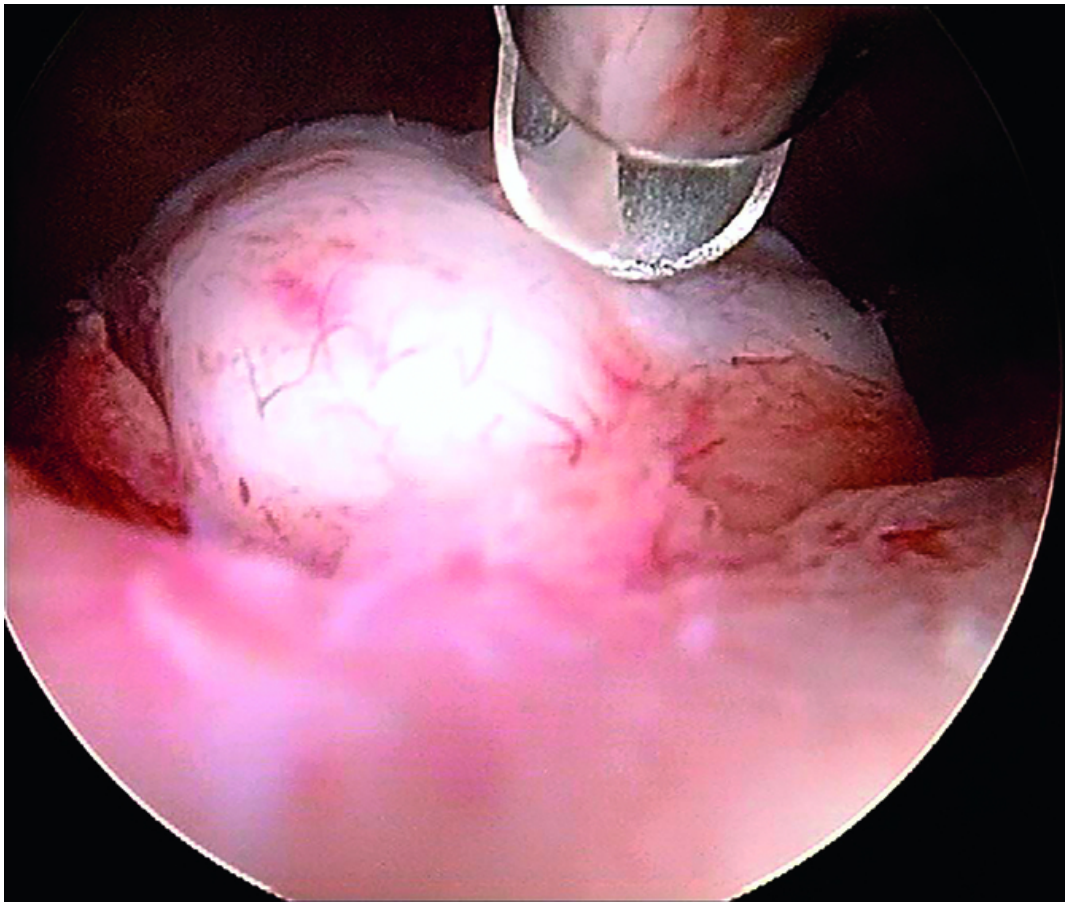


**FIGURE 21.8** Tissue retrieval system with aperture adjacent to leiomyoma. This myoma is on the posterior wall of the uterus.

The disadvantage for the current HTRS is that most of these devices not allow the surgeon to electrocoagulate bleeding vessels. If bleeding occurs during surgery, intracervical injection of a diluted solution of vasopressin may be helpful. The intrauterine pressure may be increased temporarily to tamponade blood vessels. Placement of an intrauterine Foley catheter can also be considered.

That said, the use of HTRS has a shorter learning curve for the novice surgeon compared with traditional resectoscopy.

Recent studies have indicated that quality of life (as measured by the Uterine Fibroid Symptom-Quality of Life and Health-Related Quality of Life) improves significantly 12 months after surgery with HTRS. Additional evidence denotes shorter operative time, reduction in fluid deficit, low rates of postoperative adhesions, and fewer complications. However, cost of the disposable devices exceeds that of conventional resectoscopy.

# Postoperative Recommendations

Operative hysteroscopy is generally performed in the ambulatory setting. Generally, the procedures are brief and may be performed under conscious sedation or intravenous sedation or with paracervical blocks. With the advent of smaller caliber operative hysteroscopes, a cooperative patient, and small type 0 leiomyomas, some surgeons are treating fibroids in the office with nominal anesthesia. Typically, operative hysteroscopy is safe, effective, and associated with few immediate or long-term complications.

Patients should be informed to expect spotting or bleeding for 2-4 weeks following the procedure. If the procedure is performed in the late proliferative or secretory phase of the cycle, bleeding following the procedure may stop and then be followed by another menses owing to the menstrual cycle. This can be annoying and frustrating to the patient but is normal. Likewise, patients treated with a progesterone therapy before surgery and who are asked to discontinue the progesterone therapy after the procedure may experience hormonal withdrawal bleeding. Additionally, if a progesterone intrauterine device is placed at the completion of surgery, the patient may experience breakthrough bleeding.

Following surgery, the patient may use pads or tampons for menstrual hygiene. Vaginal intercourse may be resumed within 7 days of surgery. Douching is not recommended. Patients typically experience minimal pain after operative hysteroscopy. Many patients note relief of cramping with nonsteroidal anti-inflammatory drugs or

acetaminophen. Opioids are not typically needed. Generally, a follow-up appointment is made in 4-6 weeks after surgery.

## Complications After Hysteroscopic Myomectomy

In general, the overall risk of complications from operative hysteroscopy is low, and the most common intraoperative complications are uterine perforation, hemorrhage, cervical tears/laceration, and fluid overload.

Fluid overload with systemic absorption of distention media is affected by the degree of disruption of the venous sinuses in the myometrial bed. Additionally, it is affected by length of surgery, intrauterine pressure, creation of false tracts, and transection of blood vessels. Fluid overload with saline is treated with intravenous furosemide and hemodynamic monitoring. Fluid overload with nonionic fluid medium requires close monitoring of electrolytes and consultation.

Uterine perforation most commonly occurs during cervical dilation. If a midline fundal perforation occurs, the patient may be monitored for clinical symptoms without further treatment. Lateral perforation requires a laparoscopy to exclude uterine artery injury. Anterior or posterior perforation requires evaluation for bladder or rectal injury. Perforation with an electrosurgical device requires further evaluation with diagnostic laparoscopy or laparotomy to determine if bowel or bladder injury occurred.

Excessive intraoperative bleeding is most often caused by uterine perforation. Clinical evaluation is necessary. If excessive, diagnostic laparoscopy may be required to suture the uterine defect. If uterine perforation is excluded, then diluted vasopressin should be injected intracervically and the patient monitored. If there is no improvement, then an intrauterine Foley catheter is placed for 12-24 hours and monitored. It is slowly decompressed, and the patients are observed for recurrent bleeding. If severe and uncontrolled hemorrhage occurs, hysterectomy may be required.

Delayed complications include fever, the development of intrauterine adhesions, endometritis, and infertility. Patients with increasing complaints of abdominal pain, dysmenorrhea, fever, and foul-smelling leukorrhea should be evaluated promptly (**TABLE 21.5**). The development of postoperative adhesions has been reported in 10% of patients and may be increased in patients undergoing multiple hysteroscopic myomectomies with opposing fibroids, transmural treatment of uterine fibroids, patients treated with UAE, and hypoestrogenic conditions. Postoperative office hysteroscopy a few weeks after surgery may be helpful to detect and treat filmy adhesions.

### TABLE 21.5
### Concerning Symptoms After Hysteroscopy

| |
|---|
| Fever over 101.0 °F |
| Severe and unrelenting abdominal pain, distention, and tenderness |
| Increasing complaints of shoulder pain |
| Heavy bleeding with need to change pad more than one per hour |
| Increasing passage of large clots |
| Chest pain or shortness of breath |
| Burning with urination and increasing urinary frequency |
| Fainting or passing out |
| Foul-smelling discharge with green or yellow color |
| Inability to move bowels for more than 3 d |
| Loose or watery stools two or more times a day OR bloody stools |

# LAPAROSCOPIC MYOMECTOMY

An abdominal approach to myomectomy is recommended for type 2 fibroids not amenable to hysteroscopic approach and for all type 3-8 fibroids. Data from the COMPARE-UF Fibroid Registry demonstrated that compared to laparotomy, the laparoscopic approach to leiomyoma removal is associated with better perioperative

outcomes, including less postoperative pain, reduced blood loss, shorter length of hospital stay, and faster recovery. Reproductive and obstetric outcomes are similar. A minilaparotomy, defined as 4- to 7-cm transverse incision, may be equivalent to laparoscopic surgery in patients with lower body mass index (BMI) who do not have posterior and or intraligamentary leiomyomas (**Box 21.2**).

## BOX 21.2 STEPS IN THE PROCEDURE

### Myomectomy—Abdominal, Laparoscopic, or Robotic Approach

- Preoperative administration of vaginal or rectal misoprostol
- Lithotomy position on an antislip foam (egg crate)
- Arms tucked if by laparoscopy/robot-assisted
- Insertion of uterine manipulator configured for injection of dilute methylene blue dye to identify the uterine cavity
- Insertion of trocars at the appropriate level or laparotomy incision
- Laparotomy—dissect the bladder and apply tourniquets
- Injection of dilute vasopressin into the pseudocapsule and myometrium over the fibroid
- Incision, dissection of the myometrium until the pseudocapsule is exposed
- Enucleation of the myoma by traction-countertraction
- Closure of the myometrial defect in multiple layers
- Separate closure of the endometrium if the cavity is entered
- Extraction of the leiomyoma from the peritoneal cavity

When myomectomy is planned, a decision to proceed laparoscopically may depend on many factors, such as location and

number of the fibroids as well as the skill of the surgeon. However, characteristics that increase the frequency of complications include the removal of more than three myomas, fibroid diameter >5 cm, and multiple intramural or intraligamentous fibroid location. As a general rule, a laparoscopic approach can be used if there are fewer than four myomas in different uterine locations. Also, a myoma size >10-12 cm is typically best approached by laparotomy.

Randomized clinical trials suggest a similar rate of myoma recurrence with the laparoscopic approach vs a laparotomy approach. However, patients with more than two myomas are underrepresented in clinical trials, and therefore, the available data may not be generalizable to patients with a large number of myomas. Recurrence increases with the number and depth of fibroids. In patients with more than five myomas, recurrence may be higher with a laparoscopic or robotic approach. In some circumstances, recurrence is actually persistence of disease as small fibroids are often palpated rather than seen. The lack of the ability to palpate a small myoma in laparoscopic or robotic cases can lead to missing fibroids when there are many.

After myomectomy, uterine rupture in pregnancy is very uncommon regardless of surgical approach. Case series have suggested excessive use of electrosurgery to be associated with rupture.

In patients undergoing *in vitro* fertilization, outcomes are improved by removal of clinically significant fibroids. However, the number of myomas removed during myomectomy is associated with fertility outcomes: removal of more than six myomas is associated with lower pregnancy rates, poorer pregnancy outcomes, and the need for additional fertility treatments. There does not seem to be any difference in bleeding or fertility outcomes associated with myomectomy approach. For laparoscopic myomectomy, an energy device is required for incision of the myometrium. We recommend an ultrasonic system, because this energy form may be associated with decreased blood loss and reduction in thermal injury of the myometrium.

A detailed review of imaging in the operating room allows proper surgical planning. The patient is positioned in lithotomy on egg crate

or other device to avoid slipping during the procedure, arms tucked and padded. An examination under anesthesia is performed to plan port placement. A large myomatous uterus requires higher port placement. **FIGURE 21.9** demonstrates potential port placements. If the decision is made to place the main port for the laparoscopy above the umbilicus, we recommend an initial left upper quadrant insertion to establish a pneumoperitoneum rather than directly inserting the primary device supraumbilically. The left upper quadrant trocar insertion, which is typically placed 2 cm below the left costal margin at the midclavicular line, is also useful for primary access in patients with a prior midline incision. The patient should not be placed in Trendelenburg position for insertion of the primary peritoneal cavity access device. After insertion of the left upper quadrant port, the midline trocar should be placed under direct vision.

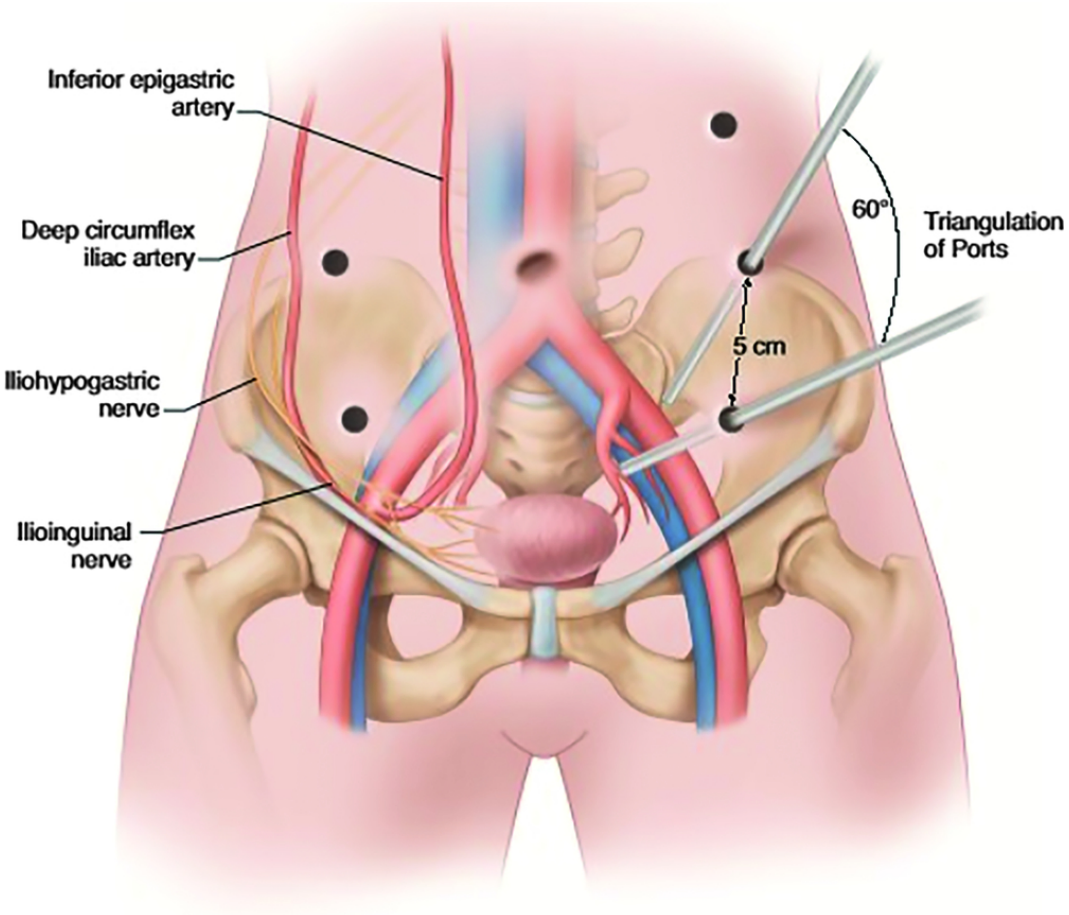


**FIGURE 21.9** Locations for lateral port site placements for laparoscopic myomectomy. Notice they are placed lateral to the inferior epigastric blood vessels and above the ilioinguinal and iliohypogastric nerves. Ports may need to be placed higher depending on the uterine size. (Reprinted with permission from Berek JS, Falcone T, Uy-Kroh MJ, et al. *Operative Techniques in Gynecologic Surgery: Gynecology*. 1st ed. Wolters Kluwer; 2017. Tech Fig 5.1.)

Under direct vision, 5-mm lateral trocars are then placed (as seen in **FIG. 21.9**). Laparoscopic suturing requires port placement that allows an ergonomic approach. To achieve this, lateral ports are typically placed at the level of the umbilicus, either lateral to the rectus muscle or in the lower quadrants lateral to the inferior epigastric vessels. The lower quadrant ports should be placed above the anterior superior iliac spine to avoid injuring the ilioinguinal/iliohypogastric nerves. The inferior epigastric vessels should be observed directly at laparoscopy. If not visible (eg, owing to obesity), the trocars are placed lateral to the insertion of the round ligament in the deep inguinal ring. Typically, four ports are placed: an umbilical port, two lateral ports on the side of the principal surgeon, and one on the side of the assistant.

A larger port, typically 10-12 mm, is required for introduction and removal of large needles. The location for this port is influenced by the plan for tissue extraction: this trocar can be placed in the anatomic area that can be extended for tissue removal. For example, if the technique for tissue removal will be through the umbilicus (eg, if an electromechanical morcellator is used), then the umbilical trocar can be 12 mm. If the extraction will be performed through a suprapubic port (eg, for manual morcellation), then the 12-mm

accessory port can be placed suprapubically and extended for extraction.

A tourniquet is difficult to apply by laparoscopy. Instead, uterine vessel clamps such as bulldog clamps can be used to occlude the uterine arteries at their origin. This requires entry into the retroperitoneal space, dissection of the ureter, isolation of the uterine artery, and then applying the temporary clamp (**FIG. 21.10**). It is a difficult procedure to perform if the uterus is so bulky to not allow adequate movement or if there are lower uterine segment leiomyomas.

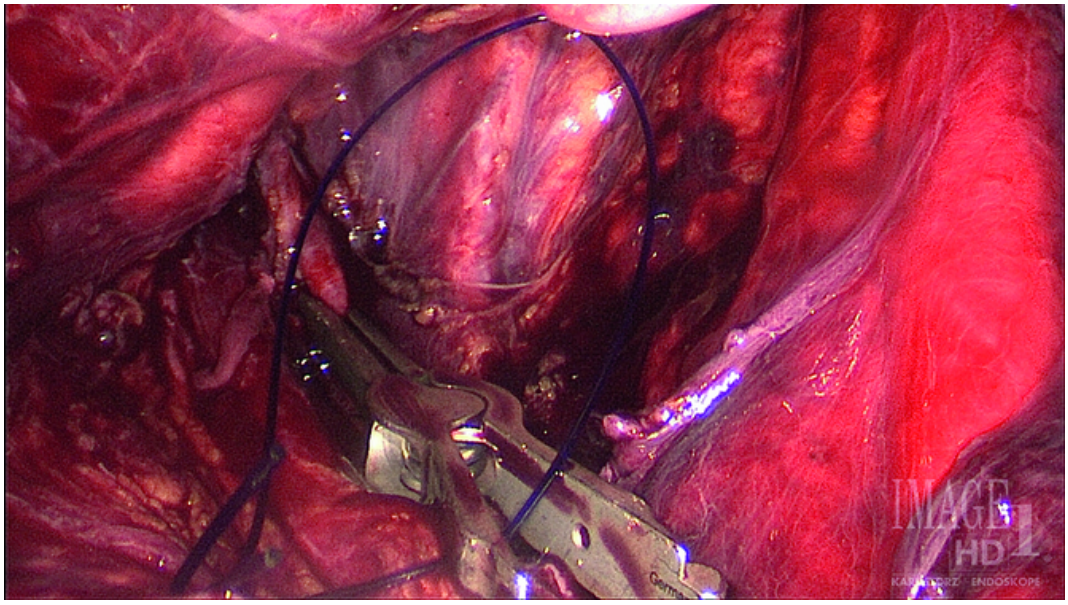



**FIGURE 21.10** The right retroperitoneal space has been opened. The laparoscopic bulldog clamp has been applied to the right uterine artery. The right ureter runs parallel to the clamp. The clamp demonstrates a suture for identification.

After a general survey of the peritoneal cavity, diluted vasopressin (20 units in 200 mL of normal saline) is injected into the myometrium

and pseudocapsule around the myoma (**FIG. 21.11**). An incision is made on the myometrium overlying the myoma, and the dissection then continues until the pseudocapsule is reached (**FIG. 21.12**). Although traditionally as many fibroids as possible are removed from a single incision on the uterus, sometimes it is necessary to make multiple incisions to achieve rapid hemostasis after enucleation. Because the vascularization of a myoma is variable (with no consistent directional pattern), the incision direction will not influence blood loss. However, a horizontal transverse incision is recommended for ease of laparoscopic suturing through the lateral ports.

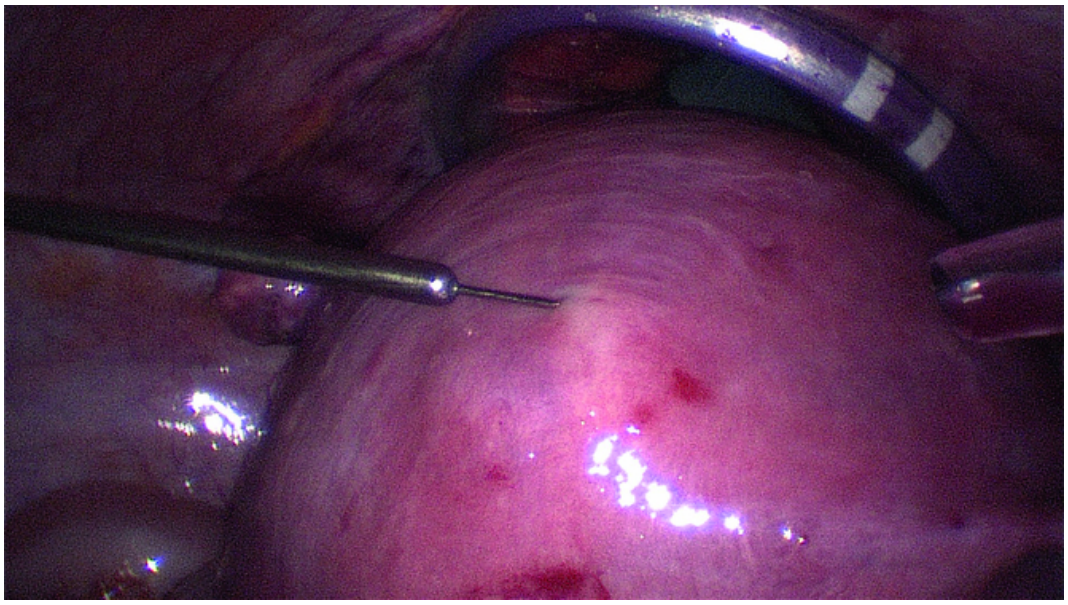


**FIGURE 21.11** Laparoscopic myomectomy—laparoscopic injection of vasopressin into the pseudocapsule and myometrium overlying the myoma.

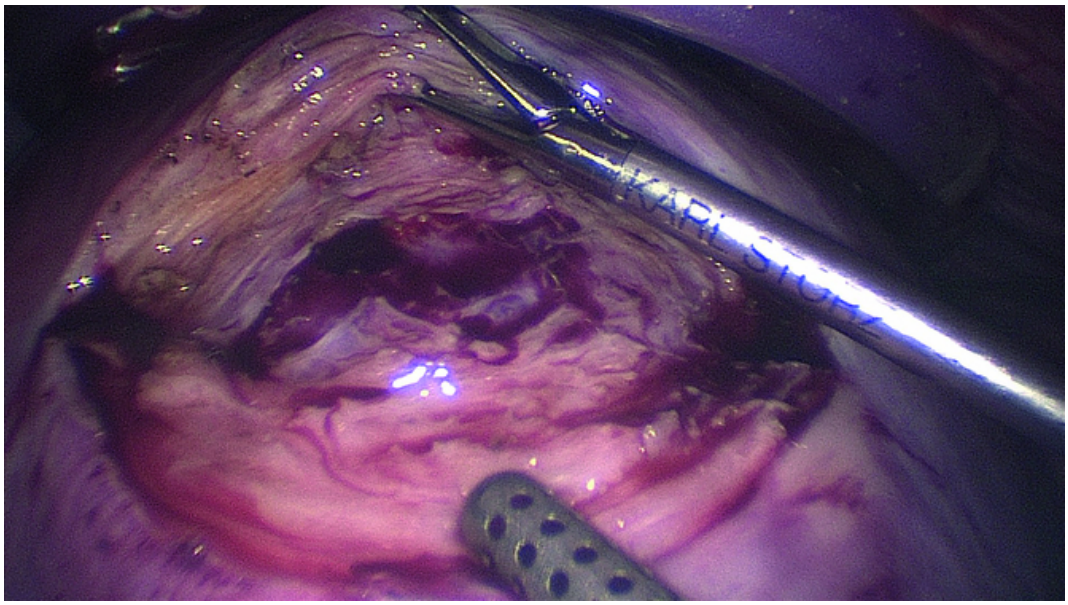


**FIGURE 21.12** Laparoscopic myomectomy—laparoscopic incision into the myometrium and dissection to the level of the myoma pseudocapsule.

Once the pseudocapsule is reached, a 5-mm tenaculum grasps the myoma to allow gentle traction-countertraction. Dissection can be accomplished with laparoscopic forceps. During dissection of deep myomas, diluted methylene blue should be injected (eg, through the uterine manipulator) to distend the uterine cavity. This makes the cavity visible during dissection and quickly identified if entry occurs. During the dissection of submucous myomas, there should be minimal pulling but rather dissection of the endometrium off the myoma. Hemostasis can be achieved with judicious use of bipolar electrosurgery. Once enucleated, the leiomyoma should be placed in an easily visible area of the pelvic cavity for later retrieval.

Closure of the myometrial defect is always multilayered. Absorbable polydioxanone, polyglactin, or barbed suture 0- or 00-gauge suture on a curved needle with a tapered tip can be used. Barbed suture may allow less blood loss and faster closure. The serosa is approximated with delayed absorbable suture in a running

fashion. The most critical step is closure of the endometrium. Inadvertent entry into the uterine cavity without separate closure could result in intracavity adhesions or obliteration of the uterine cavity. Delayed absorbable 3-0 suture is used to close the endometrium without penetrating the endometrium. There should be no suture in the uterine cavity.

In laparoscopic surgery, tissue extraction is usually performed by morcellation. Power/electromechanical or manual (scalpel) extraction techniques can be used. The FDA approved the first electromechanical technique in 1995. In 2014 and again in 2017, the FDA discouraged electromechanical morcellation and encouraged the use of a contained system for morcellation, approved to be used with laparoscopic power morcellators. Gynecologic societies opine that all existing methods of tissue extraction have risks and benefits and should be offered to patients. Informed decision-making with the patient is critical, and patients should understand that morcellation of a malignancy may worsen prognosis.

Our team's approach, with few exceptions, is to use a containment bag for morcellation. We use a suprapubic site for tissue extraction. An umbilical site is also acceptable. If an umbilical site is used for extraction, the incision is usually extended after the myomectomy is complete. If a suprapubic site is used for tissue extraction, we make the incision at the beginning of the procedure in order to use it throughout the surgery. We use an incisional retractor and cover, placed through a 4- to 5-cm suprapubic transverse incision. We typically use a GelPort device (Applied Medical, Rancho Santa Margarita, CA) (**FIG. 21.13**). This approach provides several advantages. First, the cover of this device allows placement of a 15-mm trocar, which can be used for insertion and removal of large needles for suturing during the case. Second, this approach also allows for the immediate removal of smaller fibroids (rather than placing them in the pelvic cavity for later extraction). Finally, a containment bag can be introduced through the large trocar in the retractor system (**FIG. 21.14**), allowing extracorporeal morcellation (**FIGS. 21.15** and **21.16**). An excellent closure of the myometrium can be achieved (**FIG. 21.17**).

**FIGURE 21.13** Laparoscopic myomectomy. Suprapubic containment system with trocar inserted.

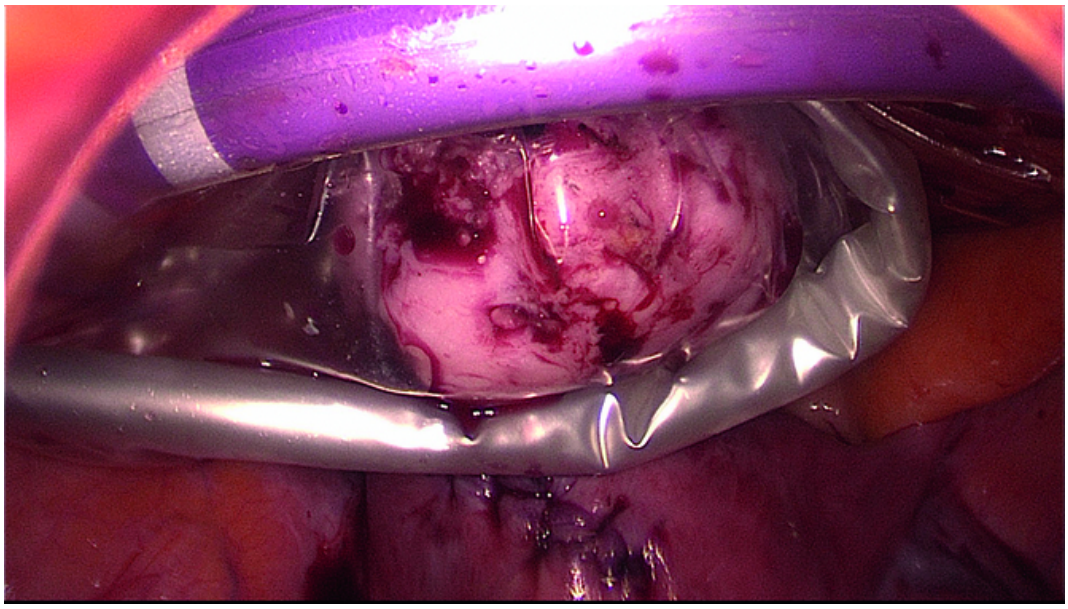


**FIGURE 21.14** Laparoscopic myomectomy. A myoma is placed in a bag, which has been introduced through the containment system. This will allow contained extracorporeal morcellation of the myoma.

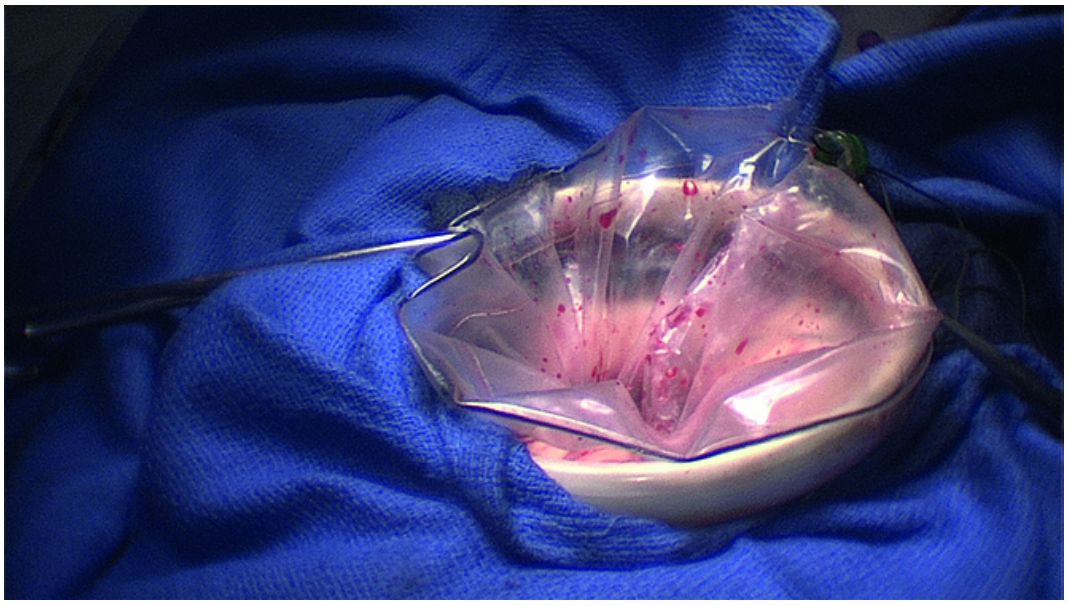


**FIGURE 21.15** Laparoscopic myomectomy—the containment bag is brought up through the suprapubic port. The Gel cap is removed, and the containment bag is brought through the opening.

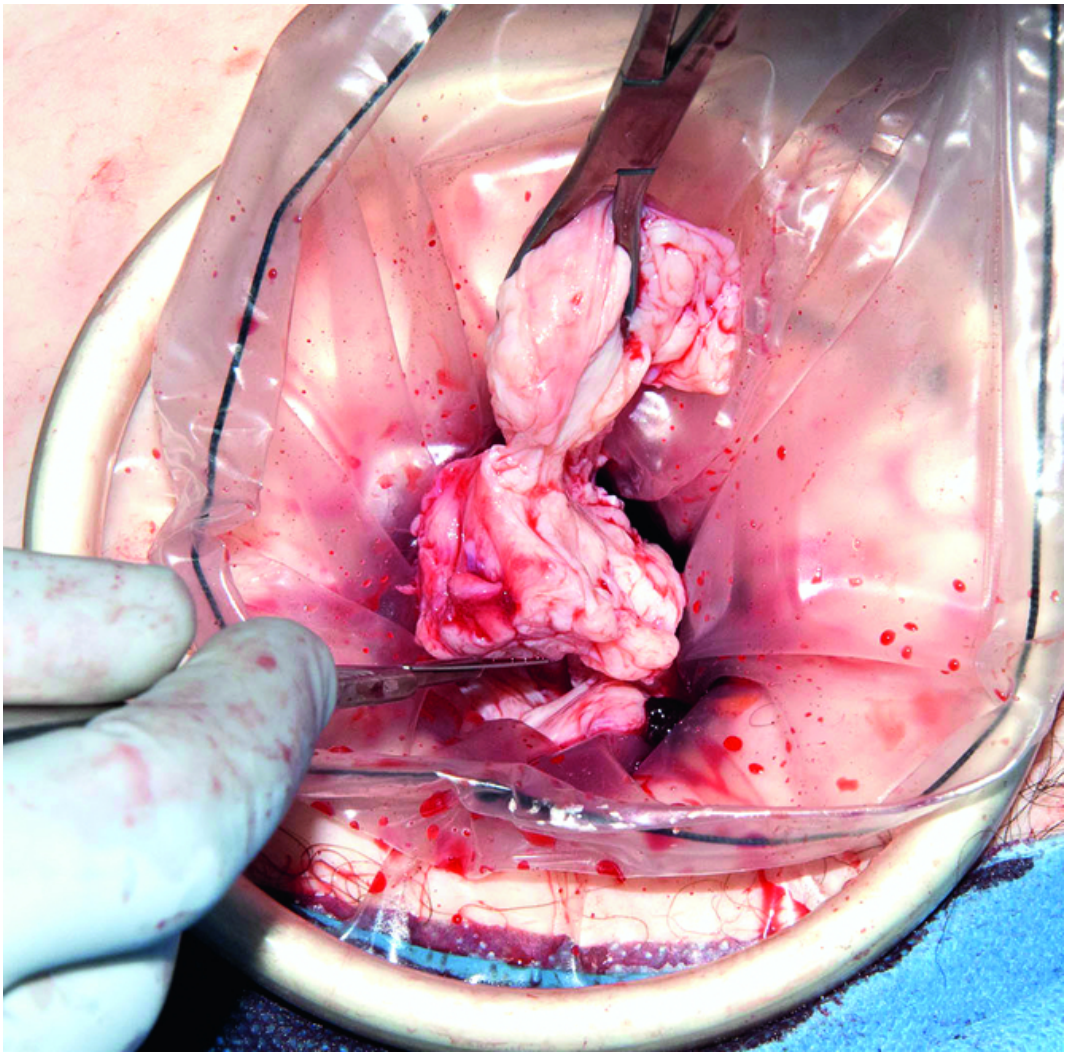


**FIGURE 21.16** Laparoscopic myomectomy—in-bag morcellation of the myoma.

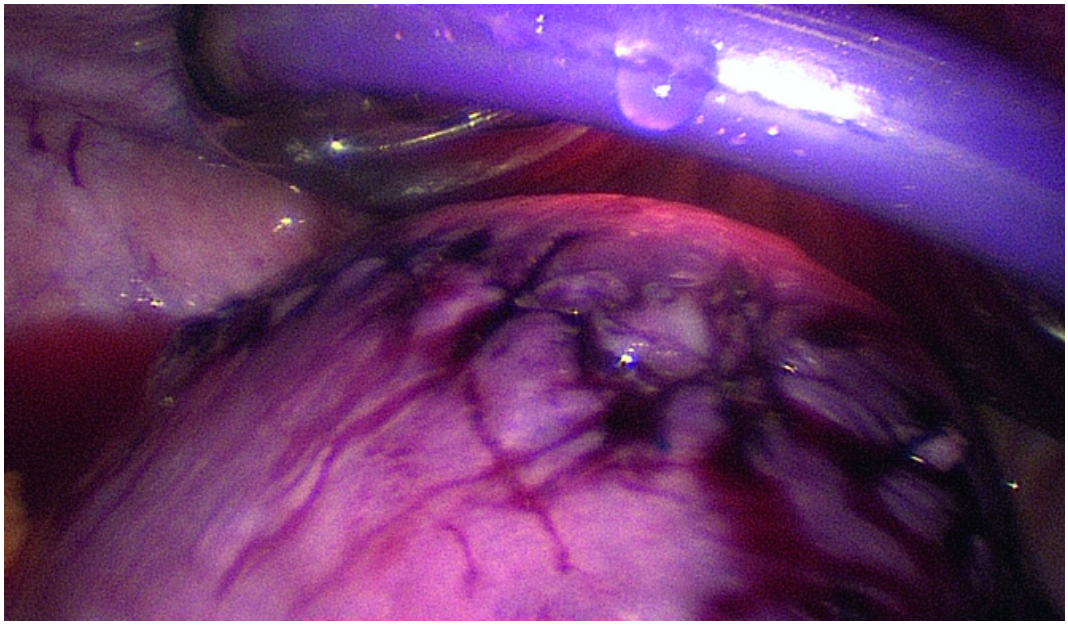


**FIGURE 21.17** Laparoscopic myomectomy—final appearance of the myometrial closure.

Antiadhesion barriers can be considered if conditions are ideal, such as no residual irrigating fluid and absolutely no bleeding or potential to bleed. Adhesion formation may increase in the presence of blood. In the setting of laparoscopic myomectomy, we typically use an antiadhesion barrier that consists of oxidized regenerated cellulose (Gynecare Interceed, Cincinnati, OH). However, there are no data that support reduction of pain or improved fertility with the use of these devices.

## ROBOT-ASSISTED LAPAROSCOPIC MYOMECTOMY

Observational trials suggest that the use of the robot (a microprocessor) allows the surgeon to accomplish more challenging surgery than conventional laparoscopy. Specifically, this technology facilitates the excision of larger myomas. Similar to conventional laparoscopy, robot-assisted surgery has significant benefit over

laparotomy for myoma surgery with faster recovery, decreased use of analgesics, and return to normal function. The investigation, preoperative preparation, and intraoperative principles are the same for robotic myomectomy as conventional laparoscopic myomectomy.

The instrumentation required for a robotic system can be expensive. For this reason, it is important to judiciously choose the correct instruments. At our center, we use three robotic arms, one for the laparoscope and two for the instruments (a bipolar grasping instrument and an ultrasonic scalpel or shears). After enucleation, these are exchanged for needle drivers. The general principles of port placement are similar. Because the endoscope must be placed at least 8-10 cm above the fundus of the uterus, supraumbilical port placement is often required. The accessory port can be placed in an upper quadrant. This can be a 10- to 12-mm port so that needles can be introduced and extracted. A tenaculum can be introduced through this upper port to manipulate the myoma for dissection. Extraction in this case is performed through an extended umbilical or supraumbilical port. If a suprapubic port is used for extraction, then a multi-instrument GelPOINT device (Applied Medical, Rancho Santa Margarita, CA) can be used, similar to conventional laparoscopy (**FIG. 21.18**).

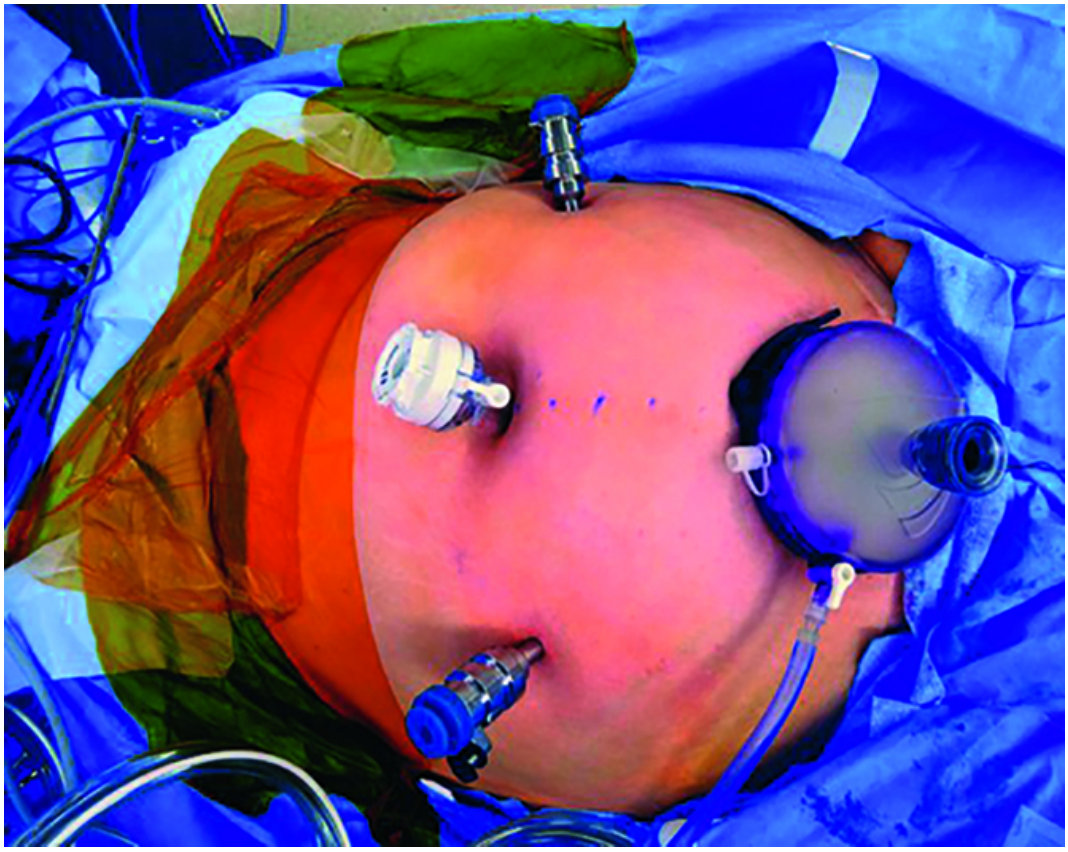


**FIGURE 21.18** Robotic port placement with suprapubic GelPort device. (Reprinted with permission from Berek JS, Falcone T, Uy-Kroh MJ, et al. *Operative Techniques in Gynecologic Surgery: Gynecology*. 1st ed. Wolters Kluwer; 2017. Tech Fig 7.3.3.)

The procedure starts with the same steps as conventional laparoscopy with appropriate patient positioning. The ports are introduced, and appropriate Trendelenburg position is achieved. A central port for the endoscope, two lateral robot ports for the accessory equipment, and a left upper quadrant 5-mm trocar for introduction of a 5-mm tenaculum are placed. The robot tower is side-docked to allow assistants to sit and manipulate the uterus or inject dye through the uterine manipulator.

The surgery proceeds in the same manner as conventional laparoscopy. Diluted vasopressin is injected, incision is made with the energy device (**FIG. 21.19**), and dissection of the myometrium should be continued until reaching the myoma pseudocapsule (**FIG. 21.20**). The myoma incision does not have to be made horizontally as robotic suturing with the articulated wrist can be accomplished with any incision direction. A tenaculum is used to allow traction-countertraction (**FIG. 21.21**). Enucleation proceeds in a similar manner as conventional laparoscopy (**FIG. 21.22**). Hemostasis is achieved with careful electrosurgery that is focused on the bleeding point only. The two instruments are replaced with needle holders. Needles are introduced and removed under direct vision through the suprapubic port. The closure of the myometrium is performed in multiple layers (**FIG. 21.23**). The myoma is placed in a containment bag and extraction and morcellated in a similar fashion as conventional laparoscopy **VIDEO 21.1**.

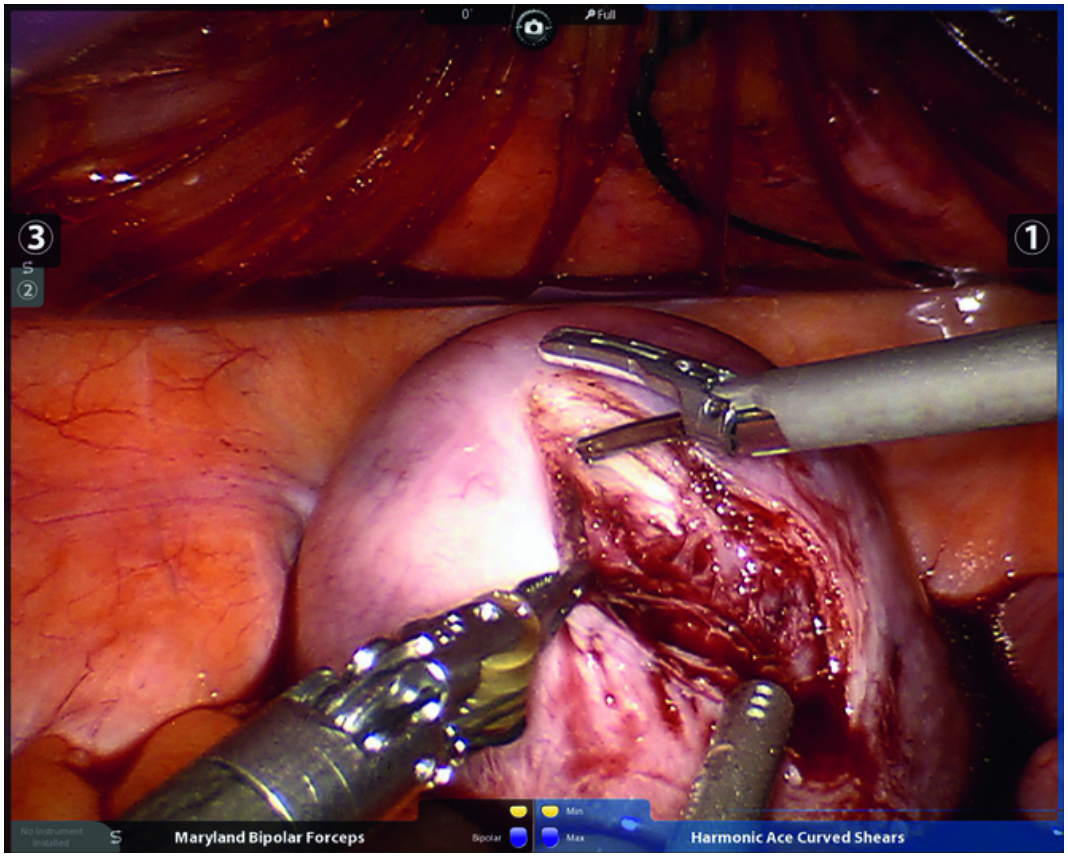


**FIGURE 21.19** Robot-assisted myomectomy—an incision is made in the myometrium with harmonic scalpel and dissected down to the myoma pseudocapsule.

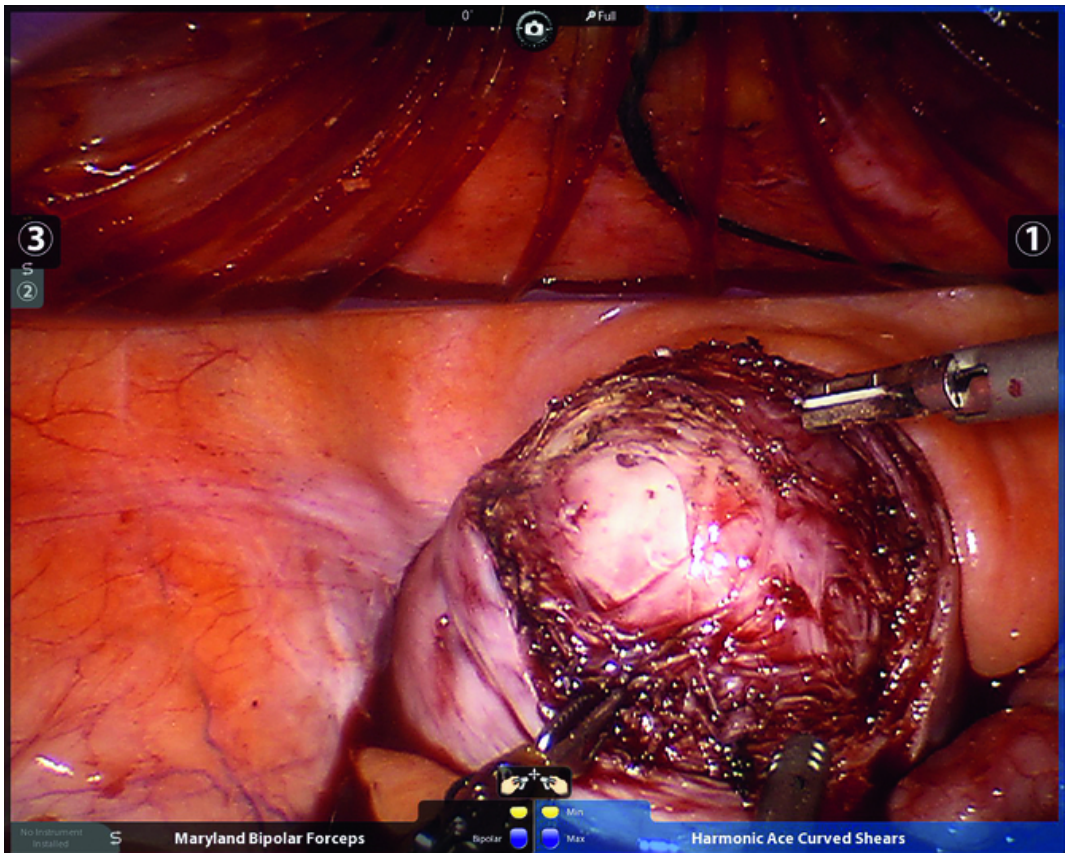



**FIGURE 21.20** Robot-assisted myomectomy—pseudocapsule is identified as the plane for dissection.

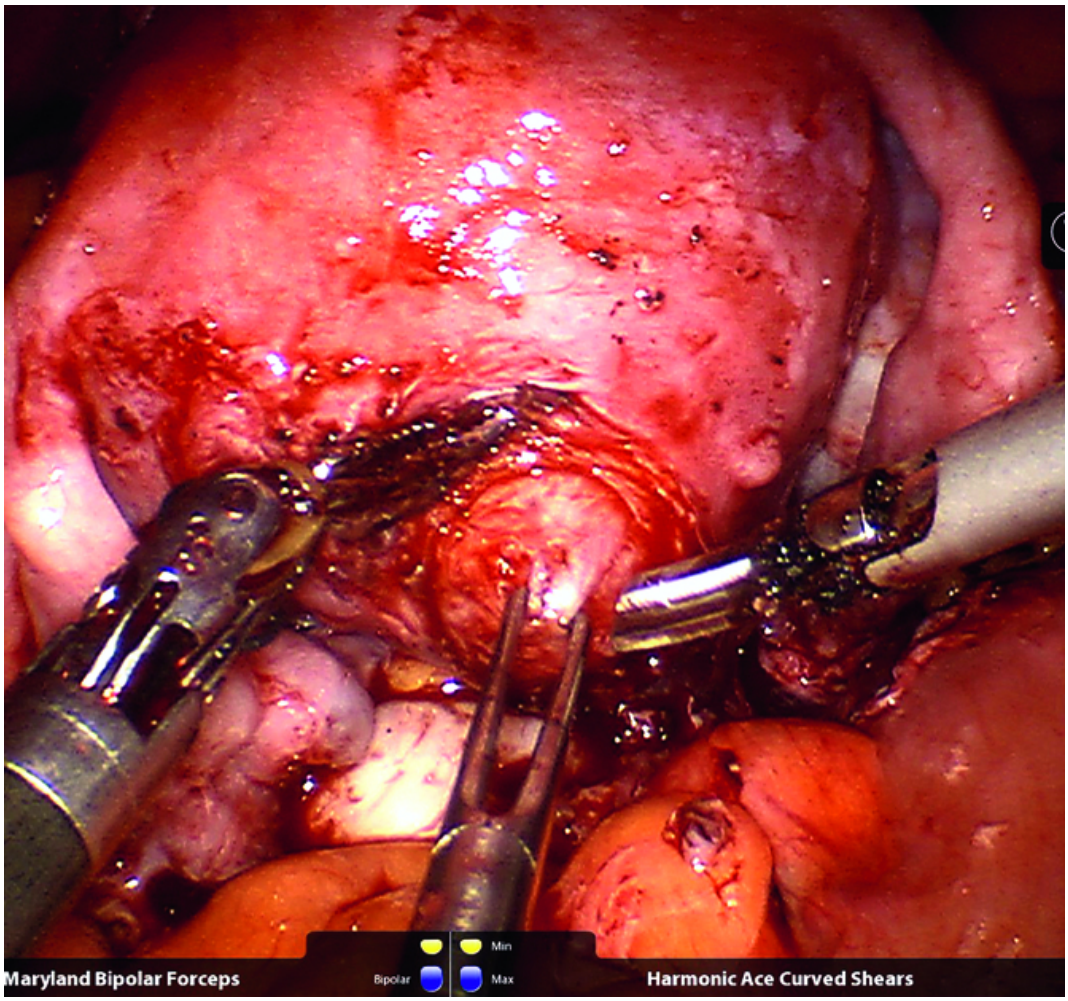



**FIGURE 21.21** Robot-assisted myomectomy—a tenaculum, placed through the left upper quadrant 5-mm accessory port, grasps the exposed myoma. This approach is ideal for the traction-countertraction necessary for enucleation.

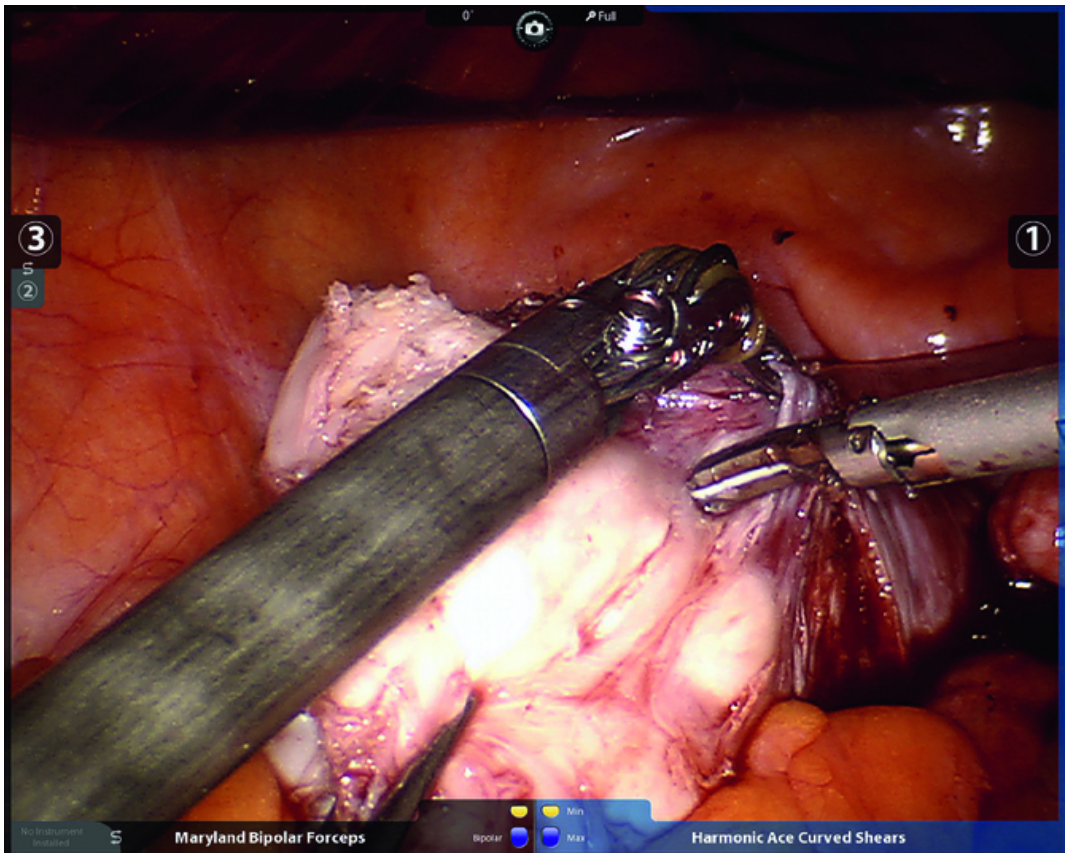



**FIGURE 21.22** Robot-assisted myomectomy—enucleation of myoma.

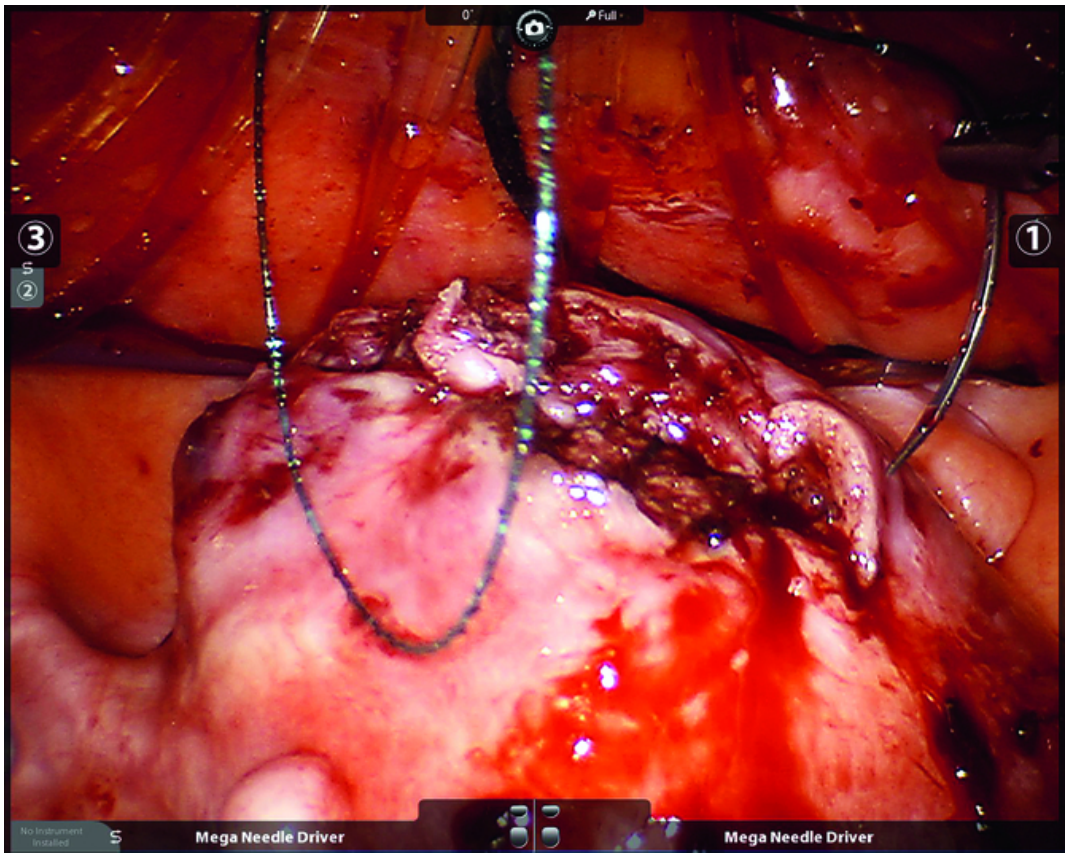



**FIGURE 21.23** Robot-assisted myomectomy—closure of the myometrium in multiple layers.

# MYOMECTOMY BY LAPAROTOMY

Depending on the skill of the surgeon, laparotomy is suggested if there are a high number of myomas, typically more than three, or myomas larger than 10-12 cm. The patient should be placed in lithotomy position for a laparotomy approach for myomectomy. This allows a uterine manipulator to be used and dye injected to correctly identify the uterine cavity during excision of myomas. The same approach to leg positioning at laparoscopy applies. The patient's arms do not have to be tucked for laparotomy. A cell saver device may be useful if removing numerous myomas. The blood lost is reinfused. Most myomas can be removed through a Pfannenstiel

incision; however, for a very large uterus, a Cherney, Maylard, or midline incision should be made. After peritoneal entry, a large uterus can be exteriorized. With exteriorization of the uterus, surgical retractors are not typically needed.

The next step is to dissect the bladder peritoneum sharply to visualize the parametrium (**FIG. 21.24**). We then place a catheter tourniquet. An opening is made in the broad ligament (close to the uterine blood vessels) using a Lahey clamp; a red rubber catheter is pulled through the resulting window. The procedure is repeated on the opposite side, and the catheter is pulled through the second opening. The ureters are below and lateral to the path of the catheter. The tourniquet can be tied anteriorly or posteriorly and held in place by a clamp to prevent loosening of the knot (**FIG. 21.25**). Application of a Satinsky vascular clamp on the ovarian vessels bilaterally is recommended to decrease all blood flow to the uterus (**FIG. 21.26**). Diluted vasopressin is then injected into the pseudocapsule (**FIG. 21.27**). An incision is made and carried to the pseudocapsule (**FIG. 21.28**). The pseudocapsule is identified, and dissection and coagulation should occur at this level to minimize blood loss (**FIG. 21.29**). A towel clamp can be applied to the myoma, and with traction/countertraction, the dissection should proceed carefully so as not to accidentally excise the endometrium (**FIG. 21.30**).

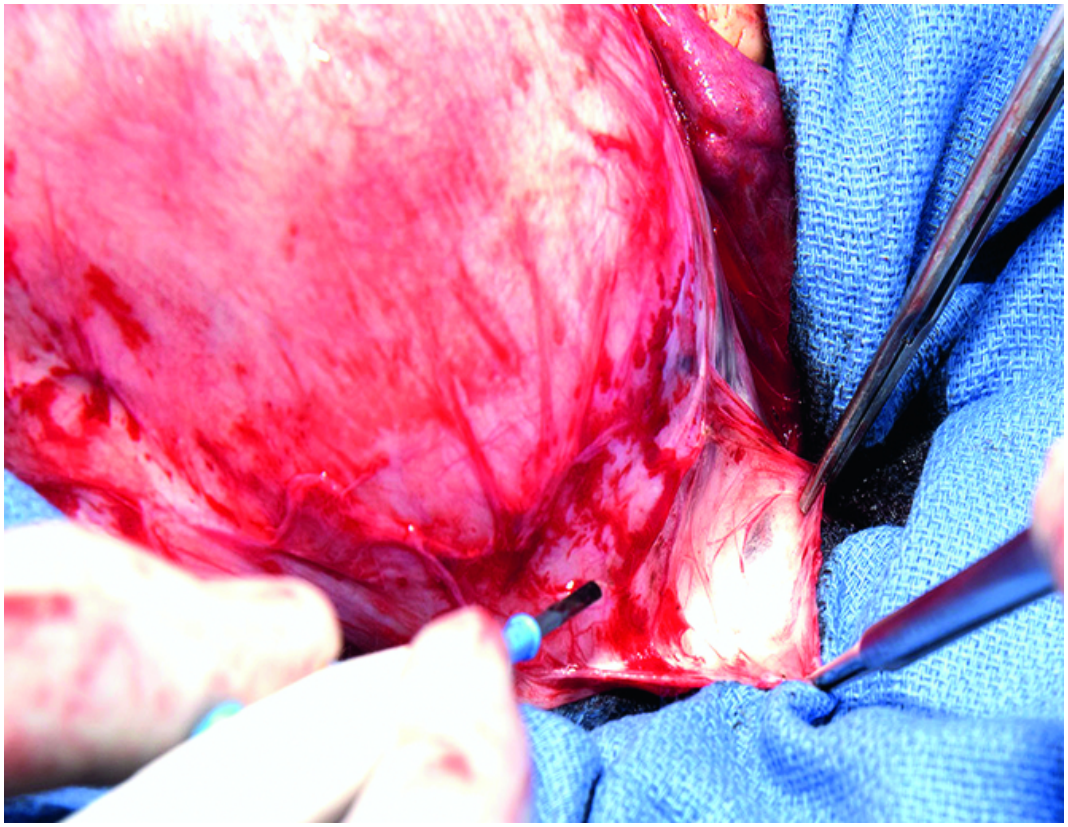


**FIGURE 21.24** Incision on the bladder peritoneum and dissected downward.

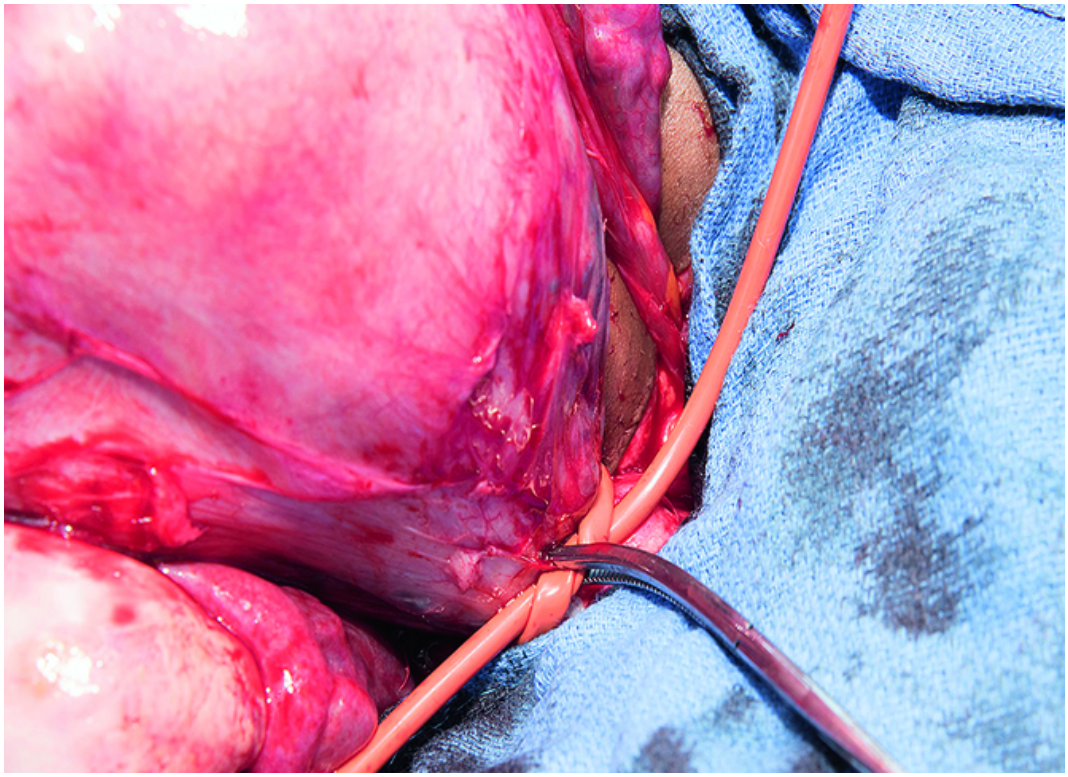


**FIGURE 21.25** A catheter is placed around the lower uterine segment in order to occlude the uterine vessels. A clamp is placed on the knot.

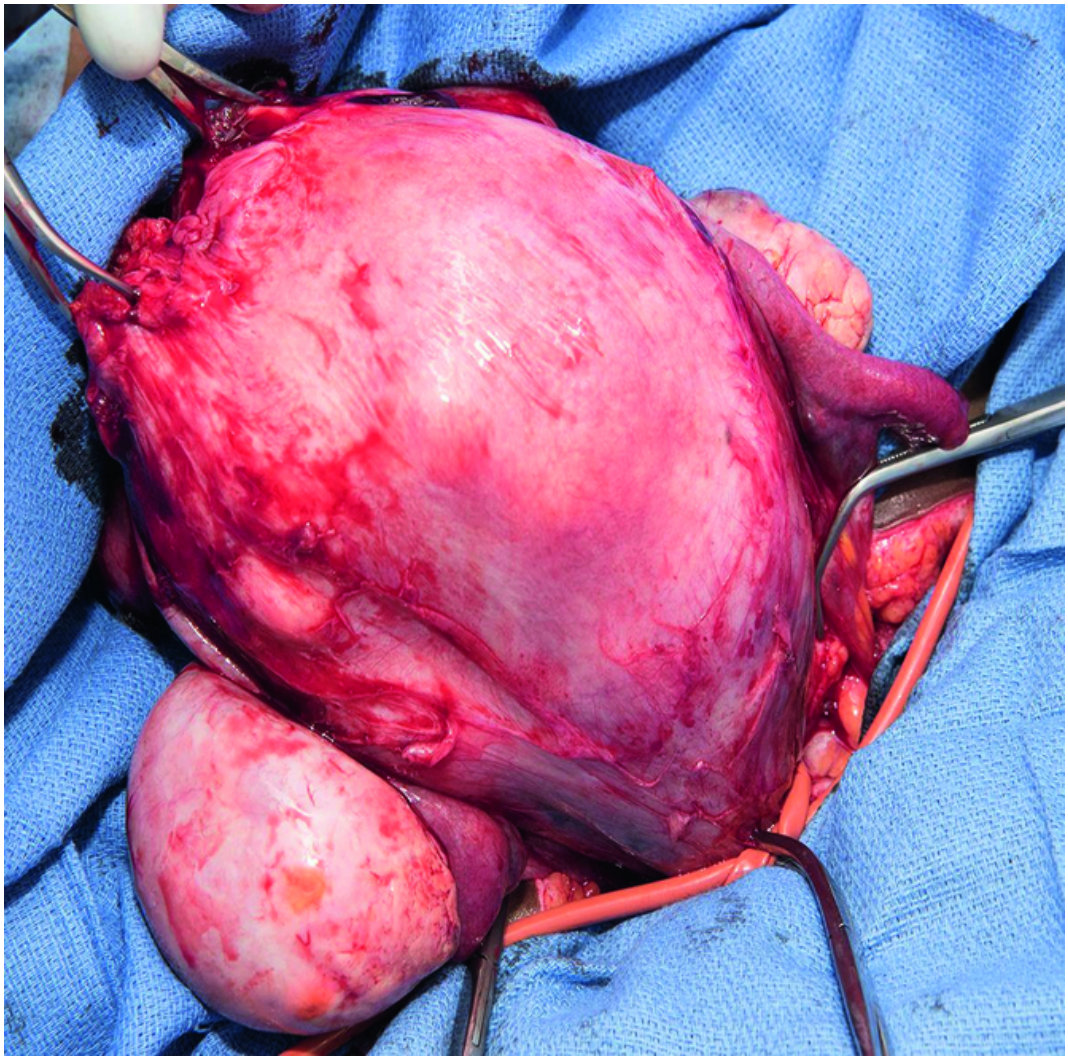


**FIGURE 21.26** A vascular clamp is placed across the ovarian vessels. The vascular clamps are placed on both ovarian vessels. The second clamp is visible on the lower left side of the image curved downward.

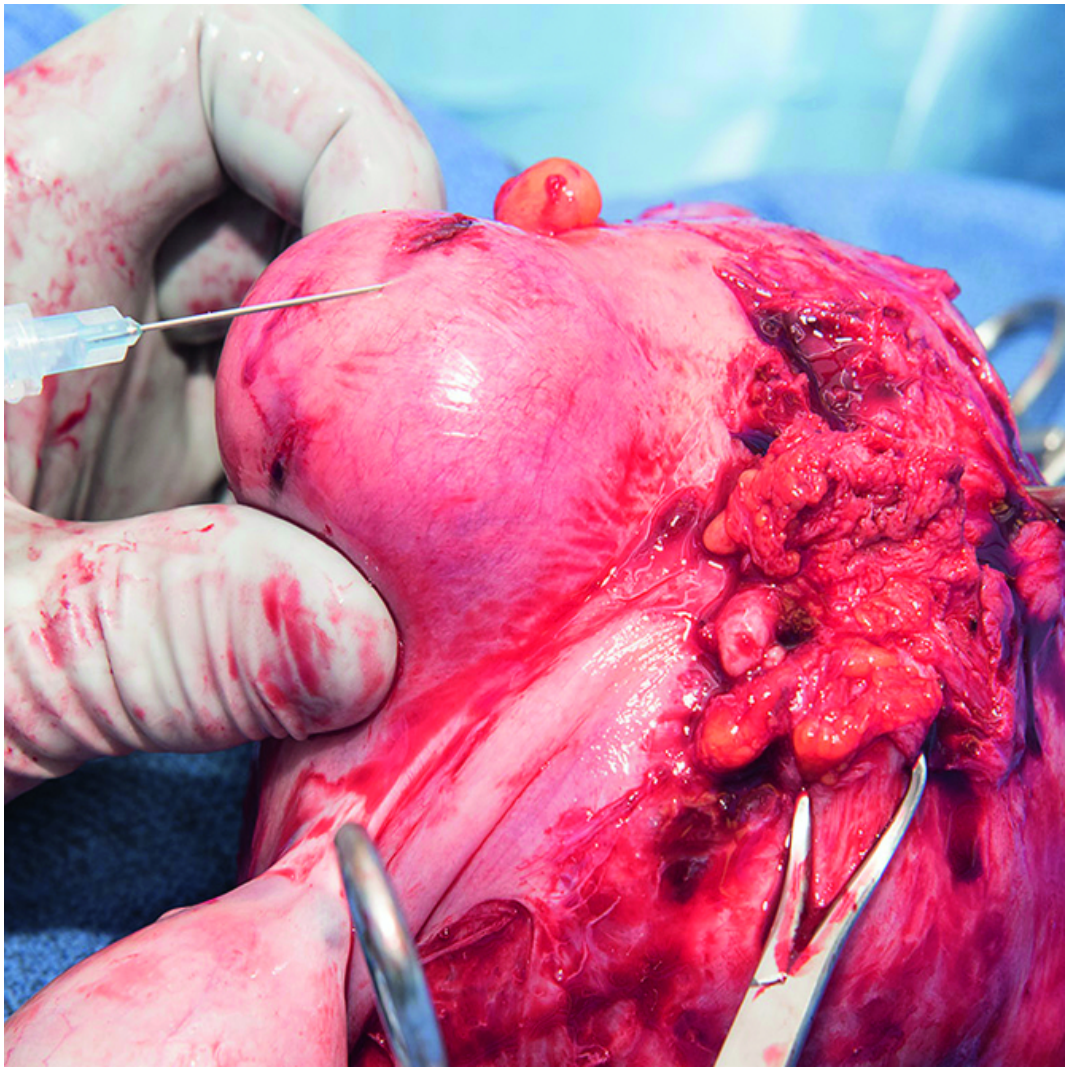


**FIGURE 21.27** Dilute vasopressin is injected into the pseudocapsule.

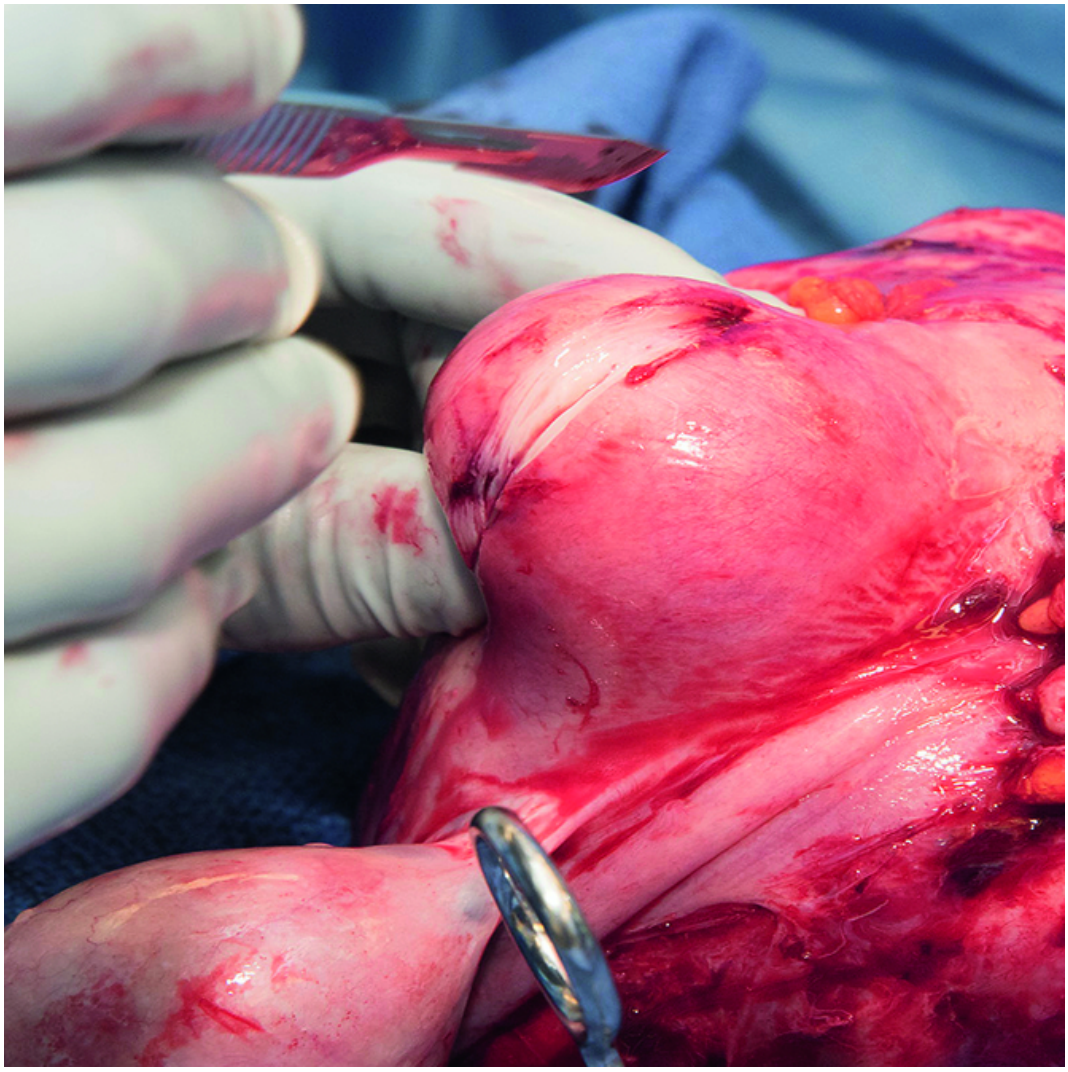


**FIGURE 21.28** An incision is made over the myometrium and continued until the pseudocapsule is reached.

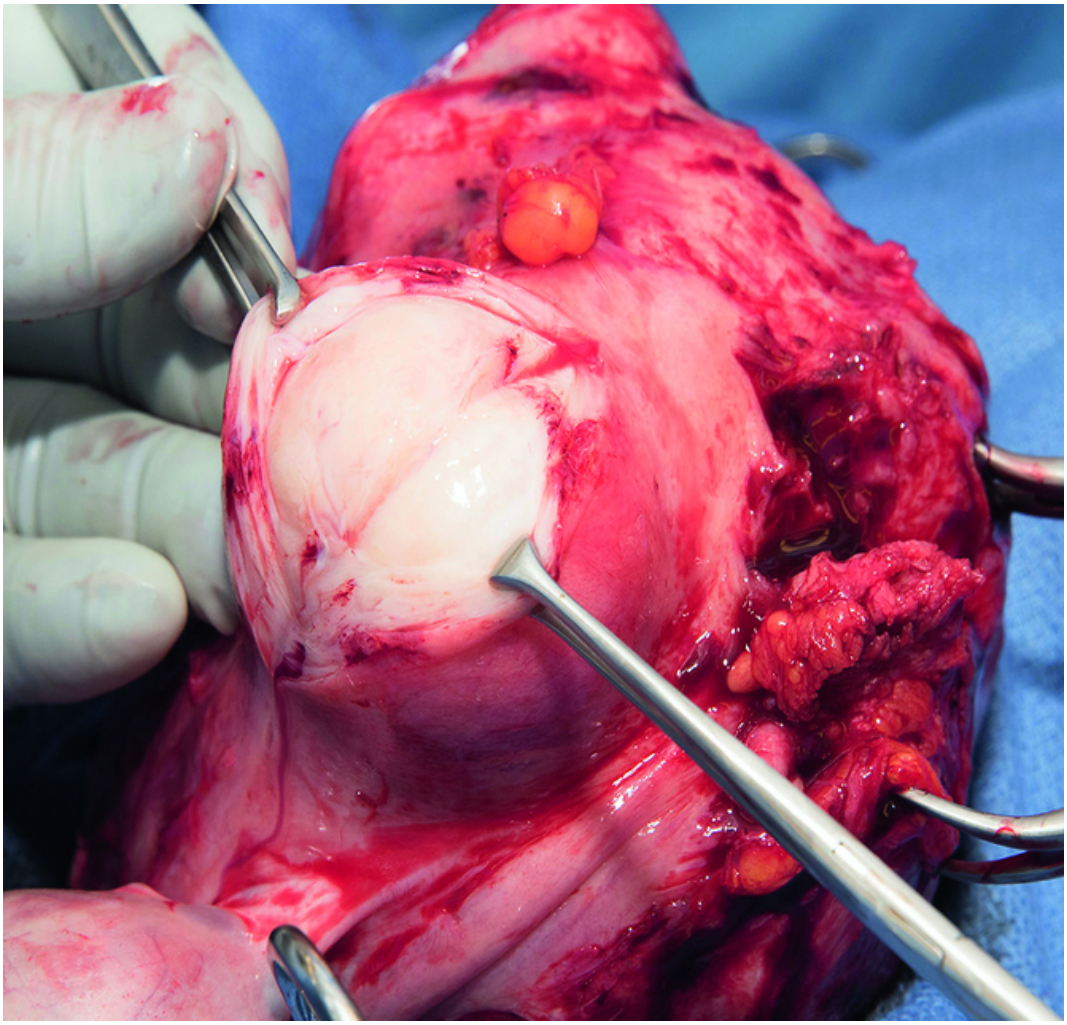


**FIGURE 21.29** The pseudocapsule is identified, and dissection and coagulation should occur at this level to minimize blood loss.

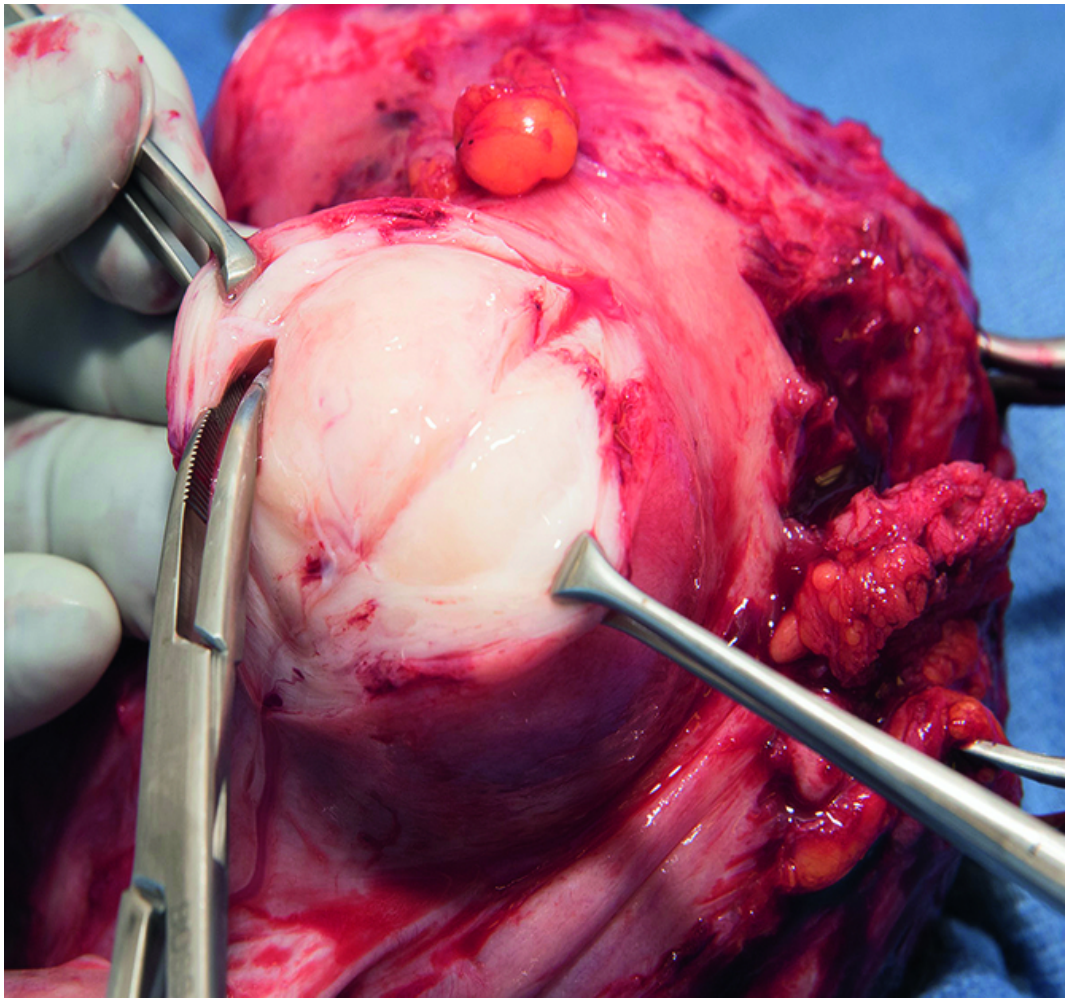


**FIGURE 21.30** The myoma is dissected from the pseudocapsule.

The principles of repair apply to all surgical approaches, minimally invasive or laparotomy. Entry into the uterine cavity requires a separate repair with fine sutures (**FIG. 21.31**). Disruption of part or all of the cervical canal or narrow lower uterine segment is challenging. Repair must be meticulous as stenosis of the cervical canal can result (**FIG. 21.32**). In cases of disruption of large or multiple segments of the endometrium, narrow lower uterine segment, or cervical canal, a pediatric Foley catheter can be placed and left in place for 1 week (**FIG. 21.33**). Excision of multiple myomas through a single incision can make effective closure challenging as the tunnel

created may make access to deep tissue difficult. Separate incisions can be made with myomas directly under the incision removed. These incisions are quickly closed with braided delayed absorbable sutures (eg, 2-0 Vicryl or Polysorb). At least two myometrial layers are required followed by a serosal layer of finer suture (**FIG. 21.34**). The tourniquet and vascular clamps are then removed, and reperfusion of the uterus will identify bleeding that requires additional sutures. Antiadhesion barriers can be used if conditions are appropriate. A large number of myomas can be removed with this technique (**FIG. 21.35**).

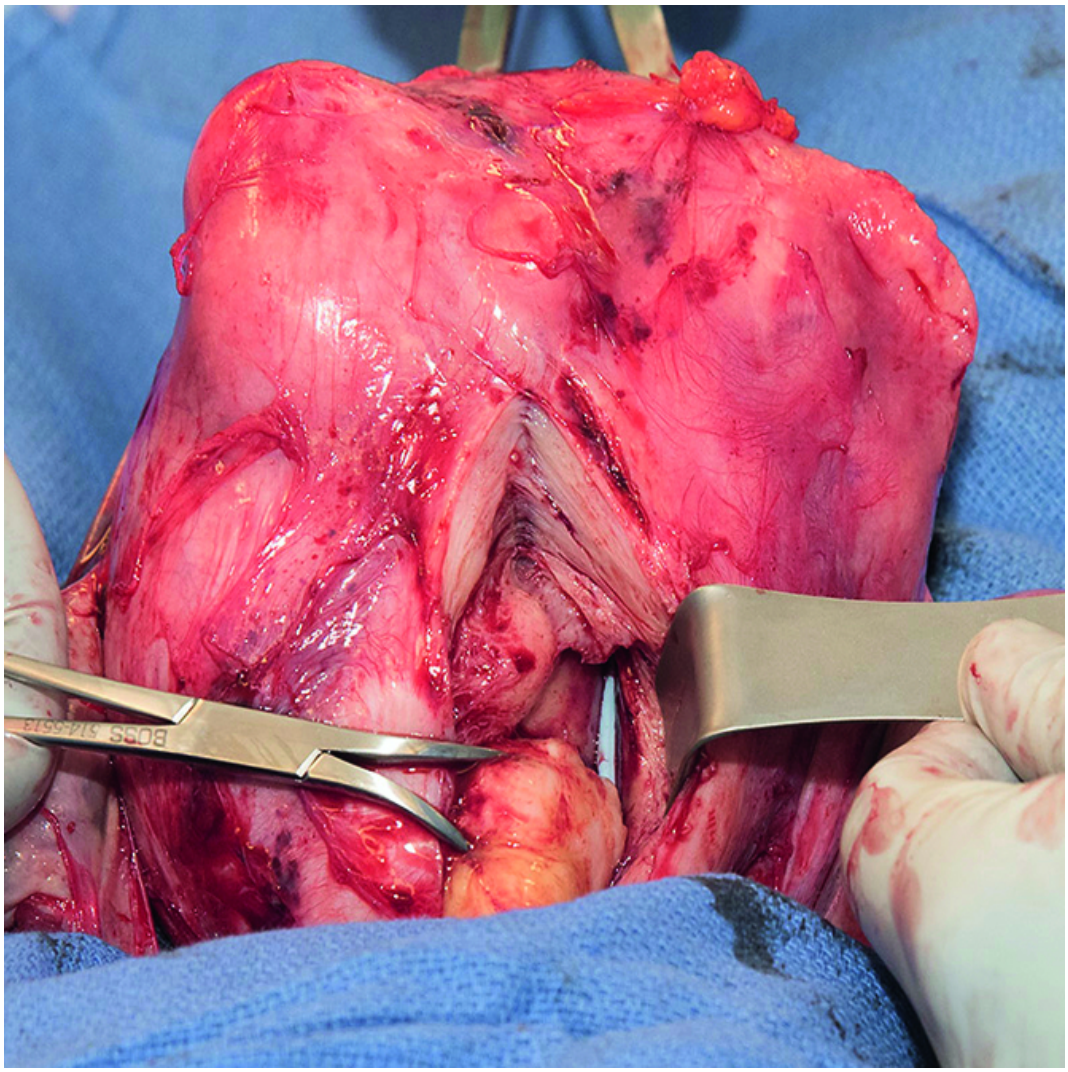


**FIGURE 21.31** The uterine cavity is entered during dissection of a submucous myoma. The pediatric Foley catheter is seen. It was inserted at the beginning of the case.

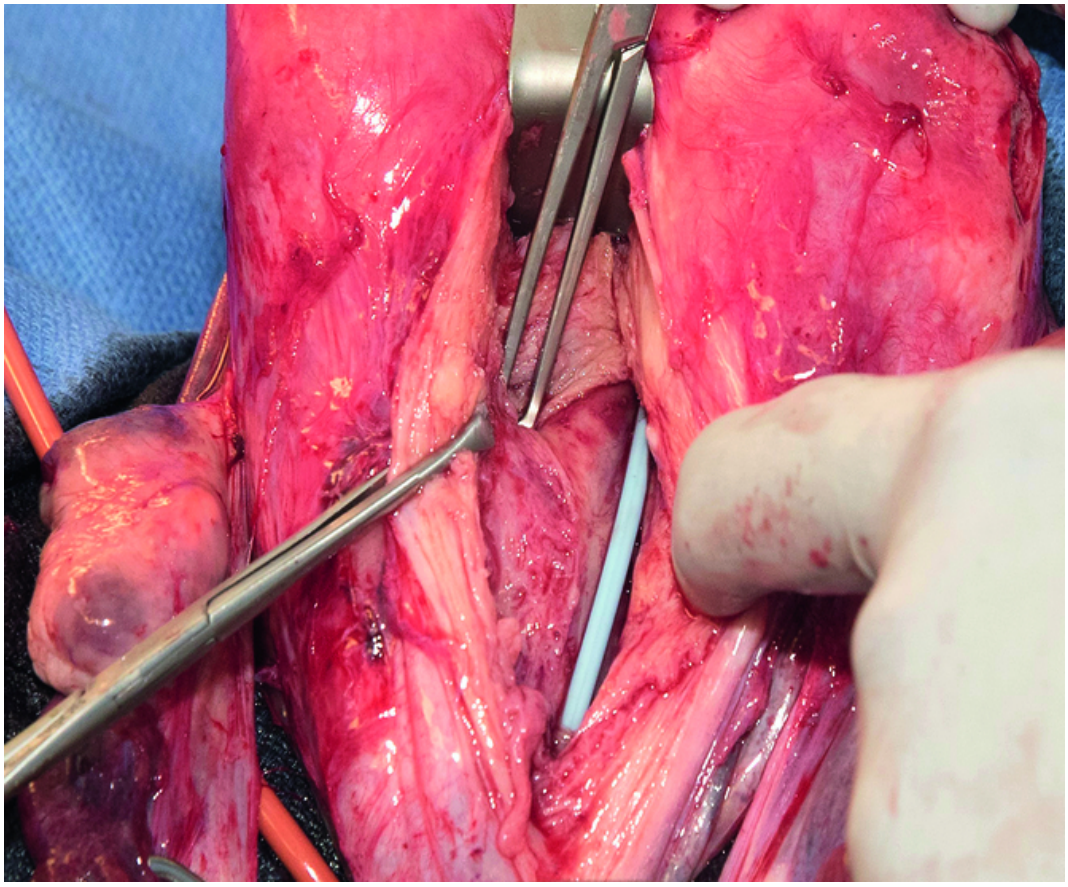


**FIGURE 21.32** The fibroid has been removed. This level is the lower uterine segment that is often lengthened because of multiple myomas. Closure at this level requires meticulous closure with fine sutures that should not be placed into the cavity. The catheter is left in to prevent stenosis.

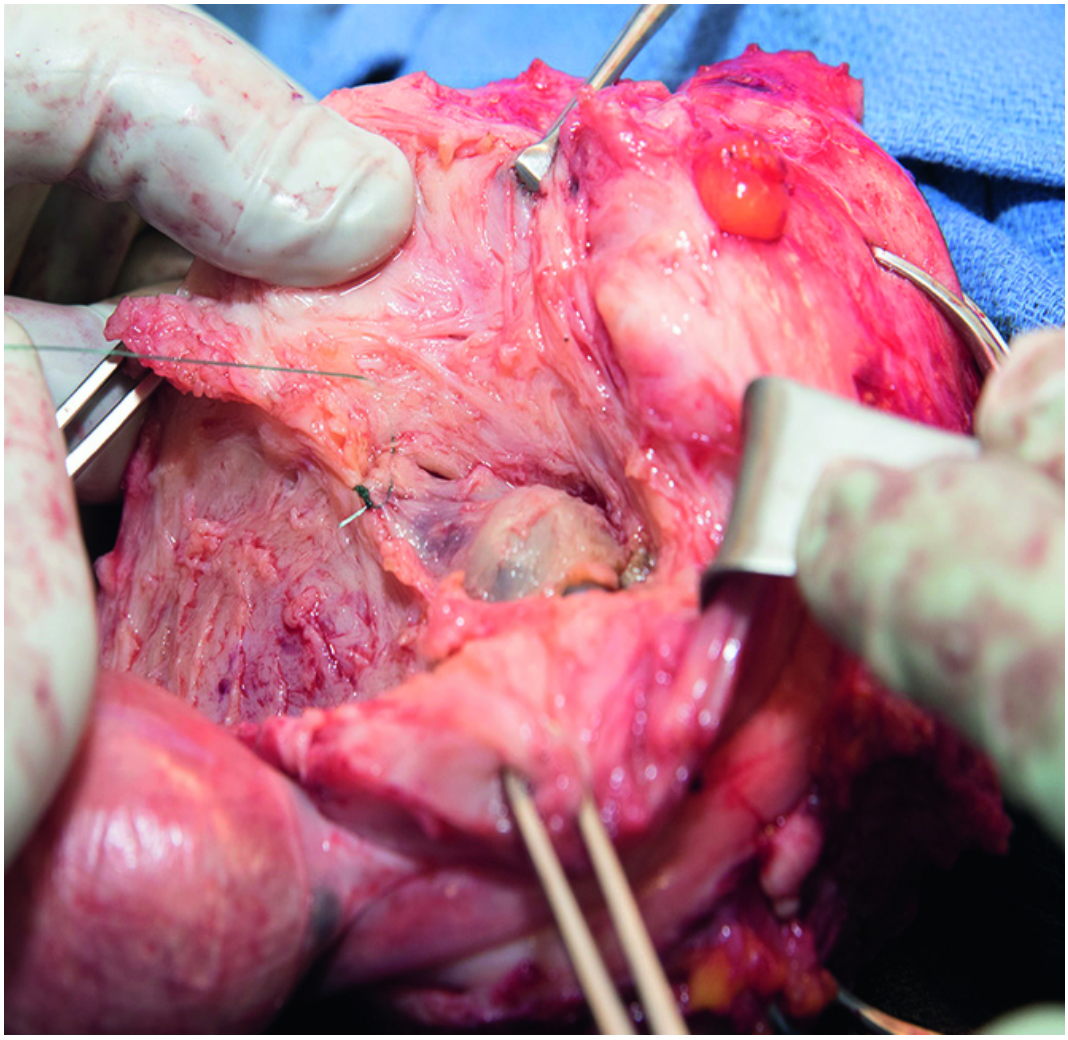


**FIGURE 21.33** A myoma was removed from its submucosal location. The cavity was not entered. The Foley balloon is seen as a bulge under the endometrium.

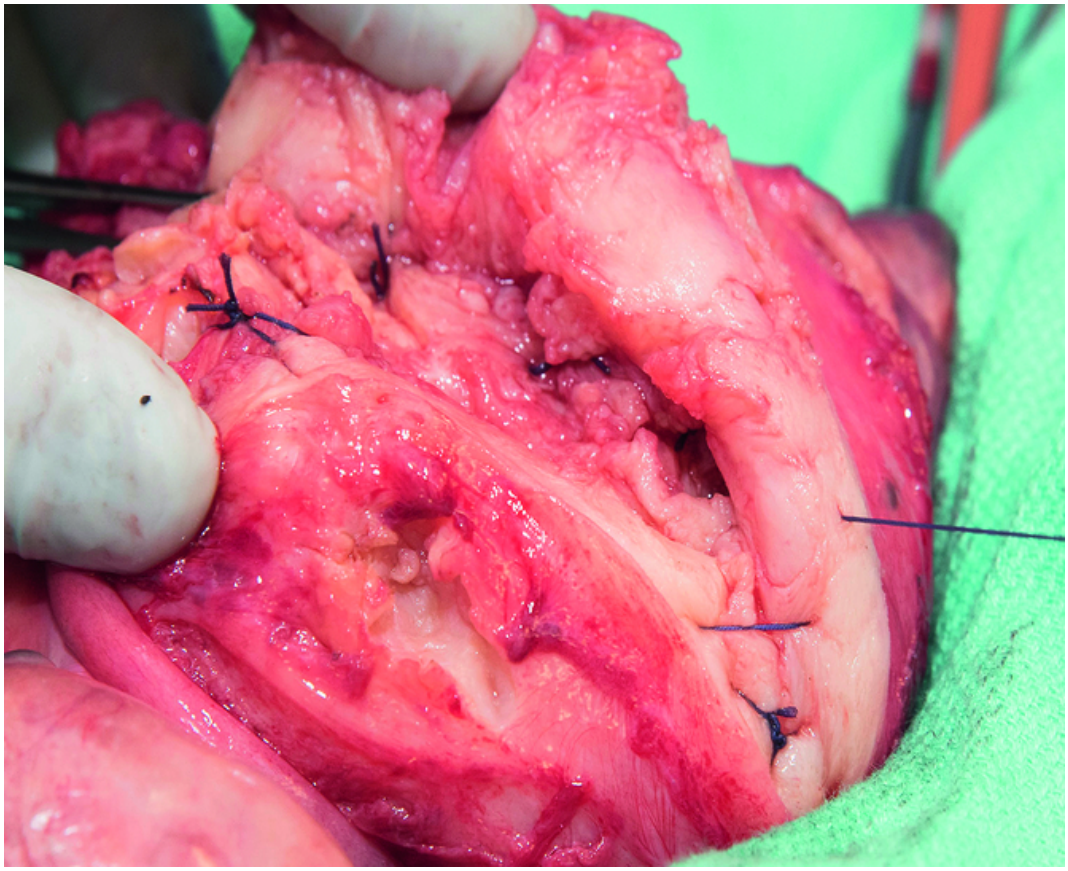


**FIGURE 21.34** The myometrium is closed in layers. Closure of the myometrium almost always requires at least two layers.

**FIGURE 21.35** Multiple myomas removed from this procedure.

# VAGINAL MYOMECTOMY

Vaginal myomectomy was first described in 1845 by Atlee who performed the procedure on a patient presenting with prolapsing pedunculated submucosal leiomyoma. Compared with other uterine locations, prolapsing vaginal fibroids are the least common. Owing to increasing options of nonextirpative leiomyoma therapies (including MRI-focused ultrasound, laparoscopic and transcervical fibroid ablation, UAE, and GnRH agonists and GnRH antagonists therapies), gynecologists may see patients with this problem more

frequently. Classic prodromal symptoms of a prolapsing uterine fibroid may include leukorrhea, colicky pelvic pain, foul-smelling vaginal discharge, menstrual bleeding with variable flow, anemia, pressure, lower abdominal discomfort, “laborlike pain,” bulge in the vagina, and difficulty with urination. Vaginal hemorrhage may occur, and the duration of symptoms is variable.

The etiology of prolapsing leiomyoma is not completely known. However, there can be transmural protrusion of leiomyoma into the uterine cavity as well as intracavitary leiomyoma that migrates through the cervix. As the uterus contracts, the leiomyoma is pushed through the endocervical canal and then causes the cervix to dilate and become effaced. In some cases, only the surface of the leiomyoma may be seen. Alternatively, the entire leiomyoma can be seen and palpated at the introitus. When a prolapsing leiomyoma appears at the introitus, it may be mistaken for uterine eversion, uterovaginal prolapse, including cystocele or rectocele. When examined, the cervix can be effaced, softened, dilated, or barely seen.

Preoperative evaluation including transvaginal ultrasound or transabdominal ultrasound is helpful to determine fibroid size. On occasion, MRI of the female pelvis is necessary to determine the entire size of the lesion and whether it has a pure intracavitary component. Once it is determined that the patient is a candidate for surgery, the patient should be prepared for surgery and consent obtained for a surgical procedure that includes operative hysteroscopy. Hysteroscopy performed after removal of the prolapsed leiomyoma is beneficial as it permits complete resection of residual leiomyoma and coagulation of the base or stalk of the leiomyoma.

Due to a concern about colonization of the upper genital tract in the setting of a prolapsed myoma, patients are usually empirically treated with broad-spectrum antibiotics perioperatively and postoperatively. If the patient is febrile, blood cultures and cervical/vaginal cultures are obtained, broad-spectrum antibiotics are administered, and the surgery is typically not performed until the patient is clinically improved. Once stabilized, the patient should be fully examined under anesthesia. Examination under anesthesia is

performed to determine if the base or pedicle of the leiomyoma is palpable.

Diluted vasopressin (20 units mixed in 200 mL normal saline) is slowly injected into the portion of the leiomyoma that is visible until leiomyoma ischemia is detected. The amount of vasopressin given varies and depends on the size of the fibroid. If the myoma is already ischemic, no vasopressin is necessary (**FIG. 21.36**). If a narrow stalk is palpable, the leiomyoma can generally be twisted off with the application of Lahey clamps (**FIG. 21.37**). Slow downward traction and rotation of the pedunculated leiomyoma will lead to extirpation of the leiomyoma. It is important to avoid pulling on the leiomyoma vigorously or rapidly as it may lead to uterine inversion. Usually, there is very little bleeding associated with this technique, and the leiomyoma should be sent for histologic evaluation.

**FIGURE 21.36** Tenaculum on effaced cervix with necrotic prolapsing fibroid.

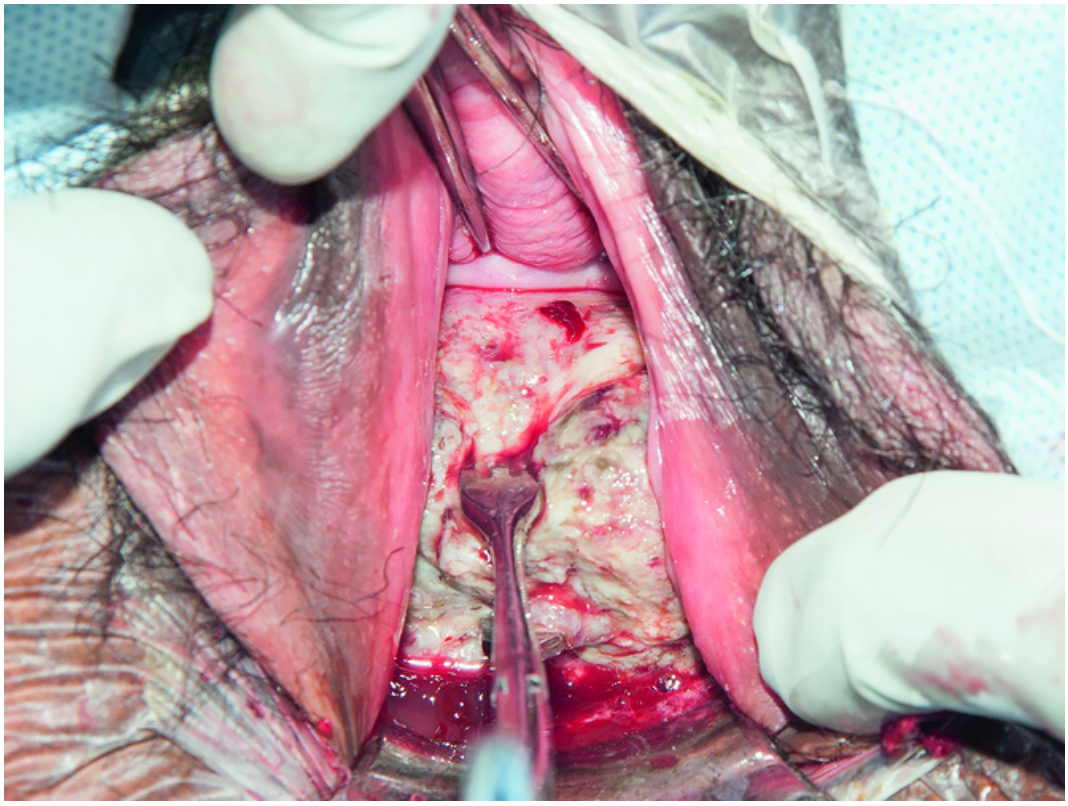


**FIGURE 21.37** A Lahey clamp is placed on the fibroid for dissection.

Laparoscopic endoloops have also been described to securely ligate the base of the pedicle as high as possible for hemostasis. If brisk bleeding occurs during the procedure, a 26-Fr, 30-mL Foley catheter can be inserted through the cervix and the balloon distended with 30 mL of sterile water. It can be left in place for 12-24 hours and deflated. If needed, the cervix can be sutured around the catheter of keep in place.

If the leiomyoma is large and cannot be removed through the cervix, it may be necessary to use Dührssen longitudinal median cervical incisions, relaxing incisions made through the cervix to release soft tissue entrapment. If the cervix can be seen, it can be injected with a diluted solution of vasopressin, and the cervix can be incised at 2, 10, and 6 o'clock positions. In one study, the median myoma size was 7 cm (range, 6-9), the median duration of surgery

was 60 minutes (range, 40-120), and median estimated blood loss was 90 mL (range, 50-150).

Although the cervix is dilated and effaced owing to the prolapsing leiomyoma, hysteroscopy can be attempted following removal of the pedunculated leiomyoma. Uterine distension may be difficult to maintain, however, without partial closure of the cervix. The cervix can be grasped with two to four atraumatic Allis clamps to close the cervix (**FIG. 21.38**).

**FIGURE 21.38** Intraoperative instrument placement while an assistant uses two tenaculums to occlude the cervix following excision of prolapsing fibroid.

Once the cervix is closed, the operative resectoscope is placed through the cervix, and uterine distention is achieved with the

automated fluid management system. Thorough inspection of the uterine cavity is recommended, and if residual or additional fibroids are noted, they can be resected as described earlier. On occasion, the uterine cavity cannot be distended owing to size and inability to securely close the cervix with the Allis or atraumatic clamps. If this occurs, the patient can be reevaluated after the recovery period, using either radiographic imaging or office hysteroscopy to determine if there are residual myomas.

Most patients, following successful and complete removal of the prolapsing fibroid, experience resolution of symptoms, low risk of recurrence, and preservation of fertility. Future delivery can be vaginal if there are no obstetrical complications.

## KEY POINTS

- Symptomatic leiomyomas may be associated with significant impairment in quality of life.
- Preoperative imaging is critical to evaluate the appropriate surgical approach.
- Type 0 myomas and type 1 myomas under 3 cm should generally be removed by a hysteroscopic approach.
- Attention to fluid management and technique is important for a successful hysteroscopic removal.
- A minimally invasive approach such as conventional or robot-assisted laparoscopy can generally be accomplished for myomectomy in patients with fewer than four myomas smaller than 10-12 cm.
- Multiple techniques are available to minimize blood loss at the time of myomectomy.
- Dissection and enucleation of the myoma should occur at the level of the pseudocapsule.
- Multiple layer closure of the myometrium is usually required.
- Separate closure of the endometrium is recommended.

■ Tissue extraction by morcellation in a containment bag should be the goal in all cases.

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# CHAPTER 22

# VAGINAL HYSTERECTOMY

John A. Occhino and John B. Gebhart

**Indications**
**Historical Perspective**
**Preferred Route for Hysterectomy**
Factors That Influence the Route of Hysterectomy
**Preoperative Preparation**
**Intraoperative Considerations for Vaginal Surgery**
Basic Surgical Principles
Technique for Vaginal Hysterectomy
**Special Considerations**
Difficult Anterior Colpotomy
Cervical Elongation
Enlarged Uterus
**Adnexectomy at the Time of Vaginal Hysterectomy**
Technique for Salpingo-oophorectomy at Vaginal Hysterectomy
**Complications of Vaginal Hysterectomy**
**Postoperative Care**
**Hysterectomy Simulation**

Vaginal hysterectomy, a natural orifice surgery, has been described as one of the “original” minimally invasive gynecologic procedures.

Vaginal hysterectomy is the preferred approach to hysterectomy for benign gynecological disease whenever feasible. This recommendation is based on the evidence which demonstrates that the vaginal approach is associated with significantly better outcomes when compared to other routes of hysterectomy. Therefore, the expert gynecologic surgeon must be equipped with the knowledge and unique skill set to competently perform this surgical procedure.

# INDICATIONS

The indications for hysterectomy (by any route) include gynecological conditions that cannot be managed successfully with conservative medical or less invasive surgical therapy. Most hysterectomies performed in the United States are for benign indications; symptomatic pelvic organ prolapse is the leading indication for the selection of the vaginal approach. Other indications for vaginal hysterectomy may include symptomatic leiomyoma, abnormal or dysfunctional uterine bleeding, dysmenorrhea and/or dyspareunia of presumed uterine cause, and premalignant conditions such as complex endometrial hyperplasia, cervical intraepithelial neoplasia, or microinvasive carcinoma of the cervix.

# HISTORICAL PERSPECTIVE

The first planned vaginal hysterectomy was performed in 1813 by Conrad Langenbeck of Gottingen. It is somewhat of a legendary tale; because he did not publish his successful completion of this procedure until 1817 by then his assistant surgeon had died, and the specimen was lost, so none of his colleagues believed the report of the operation. He was ultimately vindicated when the postmortem examination of the patient, who died 26 years later, showed that the operation had been performed and that the uterus had indeed been removed in its entirety.

Safe extraction of the uterus challenged many surgeons in the early 1900s, and the Mayo brothers, Drs. William and Charlie Mayo, worked to solve this problem. They were early adopters of the

European technique of replacing clamps with suture ligatures to secure vascular pedicles—a method that was controversial in the United States at the time. They also promoted efficient removal of the uterus and creation of a ligamentous support for the vaginal apex. In 1916, the Mayo brothers established a “Special Section of General Surgery”—namely, their first Division of Gynecologic Surgery—which was led by Dr. James C. Masson.

Noble Sproat Heaney of Chicago was another key historical figure in the evolution of vaginal hysterectomy. In 1934, he reported a series of 627 vaginal hysterectomies performed for benign pelvic disease, resulting in death in only three cases. He was considered one of the earliest proponents of vaginal hysterectomy and advocated this procedure as the primary approach for hysterectomy even in women without uterine prolapse.

At the Mayo Clinic, Dr. James Masson adopted techniques from Dr. Noble Heaney of Chicago. His successor, Dr. Virgil Counsellor, further refined the operation, optimizing exposure of the surgical field, minimizing risk to the bladder, ureters, and small and large bowel, establishing a consistent method of entry into the anterior and posterior peritoneal cul-de-sacs, systematically clamping and transecting the uterine attachments, and using transfixation stitches on all pedicles. This systematic technique could effectively remove uteri of differing size and descensus. Simply achieving a safe and efficient vaginal hysterectomy was not enough, however. To reduce the risk of posthysterectomy enterocele formation in the mid-1900s, Dr. Richard Symmonds studied various types of culdoplasty techniques and modified these to create what is now known as the Mayo-McCall culdoplasty, a vaginal apical suspension procedure routinely used as both prophylaxis and treatment for enterocele and applicable to varying vaginal dimensions. The collective efforts of these surgeon-innovators yielded the contemporary technique, which has endured, with few additional modifications, over the past 60 years.

# PREFERRED ROUTE FOR HYSTERECTOMY

Evidence suggests that vaginal hysterectomy should be the preferred route for removal of the uterus for benign disease. A 2015 Cochrane review of 47 studies, which included 5102 patients who had undergone hysterectomy via various routes (vaginal, abdominal, and laparoscopic), reported that compared with abdominal hysterectomy, vaginal hysterectomy was associated with faster return to normal activities and better quality of life. Compared with laparoscopic hysterectomy, vaginal hysterectomy was associated with shorter operating time and hospital stay resulting in a more cost-effective procedure (**TABLE 22.1**). Many national professional organizations recommend vaginal hysterectomy as the preferred surgical approach and suggest that laparoscopic hysterectomy only be performed when the vaginal approach is not feasible.

## TABLE 22.1
## Advantages of Vaginal Hysterectomy

**Advantages of the Vaginal Approach vs the Abdominal Approach**

- Shorter duration of hospital stay
- Faster return to normal activity
- Decreased postoperative febrile morbidity or unspecified infections

**Advantages of the Vaginal Approach vs the Laparoscopic Approach**

- No difference in intraoperative, short-term, or long-term complications
- Recovery time and pain scores similar
- Shorter operating time
- Lower cost

From Surgical approach to hysterectomy for benign gynaecological disease. *Cochrane Database of Systematic Reviews 2015*, CD003677.

# Factors That Influence the Route of Hysterectomy

It has been a subject of debate as to whether there are any "absolute" contraindications to a vaginal approach to hysterectomy for benign disease. A systematic review performed by the Society of Gynecologic Surgeons Systematic Review Group did not identify any patient characteristics that completely preclude a vaginal approach.

Kovac et al. was one of the first to propose an algorithm that assisted the surgeon in choosing the route of hysterectomy based on uterine size, mobility, and accessibility. In a randomized trial, when residents followed specific criteria for selection and performance of hysterectomy, more than 90% of hysterectomies for benign conditions were performed vaginally. Uterine morcellation and other uterine size reduction techniques were only necessary in 11% of cases. These selection criteria are used to determine the optimal route of hysterectomy. More recently, Schmitt et al. incorporated prior laparotomy into a decision tree algorithm and found vaginal hysterectomy was safe and feasible, even in women with perceived contraindications to vaginal hysterectomy, including no vaginal parity, prior cesarean, obesity, and an enlarged uterus **(FIG. 22.1**).

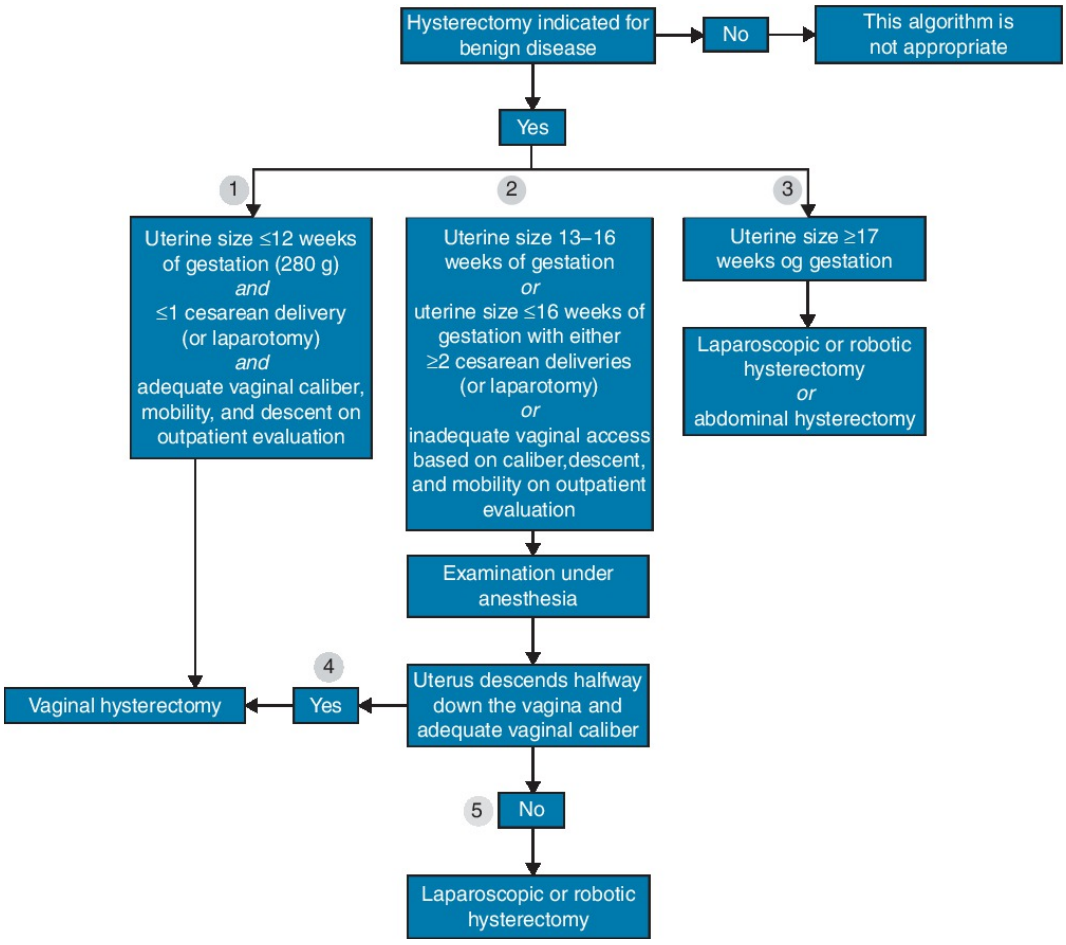



**FIGURE 22.1** Determining the route of hysterectomy. (Reproduced with permission from Schmitt JJ, Baker MV, Occhino JA, et al. Prospective implementation and evaluation of a decision-tree algorithm for route of hysterectomy. *Obstet Gynecol*. 2020;135(4):761-769. Copyright © 2020 by the American College of Obstetricians and Gynecologists.)

However, relative contraindications to vaginal hysterectomy have been identified based on anatomical or clinical factors that may

render the procedure being technically challenging. These conditions include enlarged uterus >12 weeks and extrauterine disease (adnexal masses, pelvic endometriosis, or severe pelvic adhesions). Other factors that may influence the selected route of hysterectomy include nulliparity; accessibility to the uterus (due to immobility or a narrow pubic arch <90°); prior pelvic surgery (including cesarean); the need for concurrent procedures; surgeon training and experience; available hospital technology, devices, and support; emergency or scheduled cases; and preference of the informed patient.

In such cases, preoperative planning, modification of surgical techniques, and the application of ancillary techniques can be applied to facilitate a successful vaginal approach to hysterectomy. Some of these special techniques (which will be discussed in detail later in this chapter) include uterine debulking procedures (morcellation, coring, or wedge resection) for the large uterus. Laparoscopy may also be a useful adjunct, as an intraoperative planning tool (to assess the extent of extrauterine disease), to remove a known adnexal mass, or to address adhesive disease due to scarring or endometriosis.

Nulliparity should not be a deterrent to performing a vaginal hysterectomy. Many women who are nulliparous (or who have not given birth vaginally) have adequate vaginal caliber to allow successful completion of the vaginal hysterectomy. If the vagina will allow access to divide the uterosacral and cardinal ligaments, this will usually result in enough uterine mobility to facilitate a vaginal approach to hysterectomy, even in patient with minimal uterine descensus.

A vaginal approach to hysterectomy does not preclude the removal of the adnexa. The success of removing the ovaries vaginally varies greatly and is reported to range from 65% to 97.5%. However, in a randomized trial that compared vaginal vs laparoscopic-assisted vaginal hysterectomy, the adnexa were successfully removed in 100% of the women undergoing vaginal hysterectomy, and there were more complications and increased operating time with the laparoscopic approach. Opportunistic or elective salpingectomy can also be safely accomplished at the time

of vaginal hysterectomy with success rates as high as 88% of cases in which this concomitant procedure was planned.

# PREOPERATIVE PREPARATION

Preoperative health-risk assessment should be individualized for each patient. Laboratory and screening tests should be ordered as indicated based on any underlying medical condition that could impact the surgical outcome or as part of the standard workup for the clinical indication for the hysterectomy. In certain situations, preoperative imaging is warranted. A transvaginal ultrasound may help delineate the anatomic relationship of the leiomyoma as it relates to the cervix, broad ligament, and uterine fundus. It may also be useful in preoperative planning for cases in which extrauterine pathology is suspected. If the ultrasound study does not adequately delineate the anatomy, computed tomography or magnetic resonance imaging can provide additional detail.

Preoperative counseling of the patient should include a discussion about the risk of conversion to an endoscopic or abdominal approach. Occasionally, it may be beneficial to postpone the selection of the definitive approach to the hysterectomy until the patient can be examined under anesthesia. With the patient under anesthesia in the desired surgical position, vaginal access can be assessed. This should clarify the feasibility of the vaginal approach especially in patients with limited office examinations due to morbid obesity or narrowed vaginal caliber.

There is no proven benefit to the routine use of mechanical bowel preparation prior to a vaginal hysterectomy, and it is not indicated. An enema the morning of surgery can be used to reduce the bulk of the rectum; there has only been anecdotal evidence to show the benefit for this recommendation.

The vaginal flora contains a large variety of bacterial species, including aerobic and anaerobic organisms. Vaginal hysterectomy is a “clean-contaminated” surgical procedure. Perioperative management to reduce surgical site infection is reviewed in Chapters 2 and 12. Bacterial vaginosis is a known risk factor for surgical site infection after hysterectomy. Women with this condition should be

treated preoperatively. Preoperative treatment of bacterial vaginosis with metronidazole significantly reduces vaginal cuff infection.

Perioperative antibiotics should be administered within 60 minutes of incision. These reduce the risk of infection following surgery, including reduction in the risk of cuff cellulitis after vaginal. The preferred antibiotic regimen is 2 g of cefazolin, with a 3-g dose for women who weigh more than 120 kg. For women who have had an anaphylactic reaction to penicillin (or other type of immediate hypersensitivity reaction, such as urticarial or bronchospasm) we instead recommend metronidazole (500 mg) or clindamycin (900 mg) *plus* gentamicin (5 mg/kg) or aztreonam (2 g). If surgery is prolonged, to maintain therapeutic levels throughout the procedure, cefazolin should be re-dosed after 4 hours. (Similarly, clindamycin should be re-dosed after 6 hours, and aztreonam should be re-dosed after 4 hours.) When estimated blood loss is >1500 mL, a second dose of the prophylactic antibiotic may also be warranted.

Antiseptic vaginal preparation may be performed with either 4% chlorhexidine gluconate or povidone-iodine. A systematic review demonstrated that both are appropriate for vaginal antisepsis prior to vaginal hysterectomy. It should be noted that the U.S. Food and Drug Administration has not approved 4% chlorhexidine gluconate for topical vaginal application (although this antiseptic is approved for external perioperative skin preparation). Some surgeons elect to use 4% chlorhexidine gluconate “off-label” as vaginal preparation, especially in the setting of an iodine allergy.

# INTRAOPERATIVE CONSIDERATIONS FOR VAGINAL SURGERY

A vaginal hysterectomy can be performed under general or neuraxial anesthesia, including spinal, epidural, or combined spinal-epidural anesthesia. Selection of the appropriate anesthesia type should be a joint decision made by the surgeon, anesthesiologist, and patient and should take into account patient characteristics, comorbidities, and preference. Patients with a higher risk of conversion to laparoscopy or laparotomy based on preoperative assessment may

best be served by general anesthesia. It has been shown that overall patient satisfaction with anesthesia and postoperative pain control is not significantly different between spinal and a general anesthetic. Preemptive local anesthesia (PLA) with bupivacaine prior to vaginal hysterectomy is associated with significantly lower pain scores and a reduction in narcotic use postoperatively.

# Basic Surgical Principles

Prior to the initiation of the operation, there are some key principles that should be taken into consideration when planning a vaginal hysterectomy, including proper positioning of the patient and surgeon, and maintenance of optimal exposure and lighting.

Patients are placed in dorsal lithotomy position using either candy cane or boot-type stirrups (Allen), which is left to the preference of the surgeon. We prefer the candy cane stirrups because they are less bulky, and they may provide more access and exposure for vaginal procedure, but the trade-off is that the leg position is fixed. Thus, if there becomes a need to convert to an abdominal approach, the patient will have to be repositioned. Boot-type (Allen) stirrups have the advantage of allowing the surgeon to change the patient's position intraoperatively; however, because of the bulk of the stirrups, assistants may not be comfortably accommodated within the stirrups. Regardless of the stirrup used, the key is to avoid neurologic injury by preventing hyperflexion or significant external rotation of the hip. "Protective positioning" is required to avoid injuries due to pressure ulcers and nerve compression. Patients who have impairment in range of motion or chronic pain of their back, hip, and lower extremities, regardless of selected anesthesia type, may be positioned in lithotomy fully awake to assess for any aggravation of discomfort prior to sedation. If the patient reports intolerance to the positioning, adjustments can then be made to assure comfort before the induction of anesthesia.

Careful positioning of the patient with the buttocks at the edge or over table with slight Trendelenburg will result in a pelvic tilt to achieve optimal exposure for the surgeon and assistants. Adequate

padding of the legs and underneath the sacrum may be needed in thinner woman to avoid peroneal and sciatic injury.

Ergonomic considerations are important for the surgical team as many vaginal surgeons report work-related musculoskeletal disorders. Surgeons can stand or sit for the vaginal hysterectomy regardless of the position. Singh et al. found that surgeons reported more discomfort when standing for vaginal hysterectomy as compared to sitting. Assistants to the surgeon should also be as comfortable as possible during the operation. Members of the surgical team should be careful not to lean on the patient. The height of the operating table and the surgeon's chair should be adjusted so that the assistant is able to fully access the surgical field to allow countertraction and placement of instruments to assist with retraction throughout the surgery. Exposure can also be achieved with self-retaining retractors like the Magrina Bookwalter fixed retraction (**FIG. 22.2**). Exposure may also be improved by suturing the labia laterally.

**FIGURE 22.2** Magrina Bookwalter self-retaining vaginal retractor. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

Overhead lights should be focused down the long axis of the vagina with minimal lateral deviation. Using a fiberoptic light source may also increase visualization. If vaginal access is limited (and when removing the adnexa), many surgeons prefer surgical headlights, lighted retractors, or lighted mats (a disposable light source that can be attached to any retractor).

# Technique for Vaginal Hysterectomy

Every vaginal hysterectomy should begin with an examination under anesthesia to assess for any abnormalities of the genital tract and confirm ability to proceed with the vaginal approach. This includes thorough inspection of the pelvic arch, vaginal caliber, and uterine size, shape, mobility, and descent. Performing a rectovaginal examination may also aid in the evaluation of the adnexa and for any extrauterine pathology.

The decision to empty the bladder at this time should be left to the discretion of the surgeon. We prefer a straight catheterization prior to the surgery, while others may place a Foley catheter to allow continuous drainage during the case with the option for intermittent clamping if a more distended bladder is needed to aid in the dissection. Some surgeons prefer to postpone drainage of the bladder until after entry into the anterior cul-de-sac, thus confirming a bladder injury with a “gush” of fluid during the anterior dissection. There is no difference in the risk of inadvertent bladder injury with any of these methods. If a Foley catheter is placed, it should be done after the patient is prepped and draped to avoid the need to have compromise the sterile field if removal and replacement of the catheter is needed during the surgery (**BOX 22.1**).

# BOX 22.1 STEPS IN THE PROCEDURE

## Vaginal Hysterectomy

## Positioning

*Dorsal lithotomy with buttocks positioned at the end of the table or slightly off the table to achieve full access for surgeon and surgical assistants*

## Examination under Anesthesia

- Confirm ability to proceed with vaginal approach to hysterectomy.
- Evaluate pelvic arch and vaginal caliber.
- Assess size and architecture of the uterus and mobility (uterine descent).
- Rectovaginal exam may be performed to assess adnexa and for any extrauterine pathology.

## Vaginal Incision

- Consider emptying the bladder with straight catheterization or placement of a Foley catheter (the decision to drain the bladder is based on surgeon's preference).
- Infiltrate vasoconstrictive agents into the vaginal epithelium if desired.
- Grasp both lips of the cervix.
- Locate the cervical-vaginal junction.
- Make a circumferential incision through full-thickness vaginal epithelium.
- Retract bladder anteriorly with a vaginal retractor.
- Elevate anterior vaginal epithelium and continue dissection until the peritoneum is encountered.

- Sharply incise the anterior peritoneum to gain entry into the anterior cul-de-sac.
- Confirm entry by visualizing intraperitoneal organs.
- Incise the posterior peritoneum.
- Confirm posterior cul-de-sac entry.

## Separate Ligamentous Attachments

- Clamp the uterosacral ligament with a Heaney clamp.
- Cut and suture ligate the uterosacral ligament.
- Palpate the ureter.
- Grasp the cardinal ligament with a Heaney clamp.
- Cut and suture ligate the cardinal ligament.
- Proceed with anterior entry into the anterior cul-de-sac if not already accomplished.

## Secure the Blood Supply

- Identify the uterine vessels.
- Secure the uterine vessels between the anterior and posterior peritoneum with a Heaney clamp at the level of the internal os.
- Cut and suture ligate.

## Deliver the Fundus Posteriorly

- After the blood supply is secured, grasp the fundus of the uterus.
- Deliver the uterine fundus through the posterior cul-de-sac.
- Secure the utero-ovarian vessels/ligaments; typically, clamped and suture ligated.
- Remove the uterus.
- Proceed with adnexal removal if desired.

## Cuff Closure

- Attach the cuff to the uterosacral ligament for apical support; consider McCall culdoplasty.
- Close the peritoneum.
- Perform cuff closure either in an interrupted or running fashion.
- Perform cystourethroscopy to document bladder and ureteral integrity.

## *Vaginal Incision*

Once the patient has been properly prepped, draped, and positioned with slight Trendelenburg, a short bill weighted speculum is placed into the posterior vagina, and Deaver retractors are positioned in the vagina at the 3, 9, and 12 o'clock positions (**FIG. 22.3**). The cervix is grasped with traction on the cervix using a toothed forceps, the anterior and posterior lips of the cervix are grasped with a double-toothed tenaculum. Using the double-tooth tenaculum, the cervix is placed on traction toward the introitus. The anatomical relationships of the bladder, anterior and posterior cul-de-sacs, and uterosacral ligament complex are reassessed at this time. The vaginal-cervical junction is also identified, and the ideal locations for the anterior and posterior vaginal incisions are determined (**FIG. 22.4**). Injection of local anesthetic into the uterosacral ligaments may be done at this time.

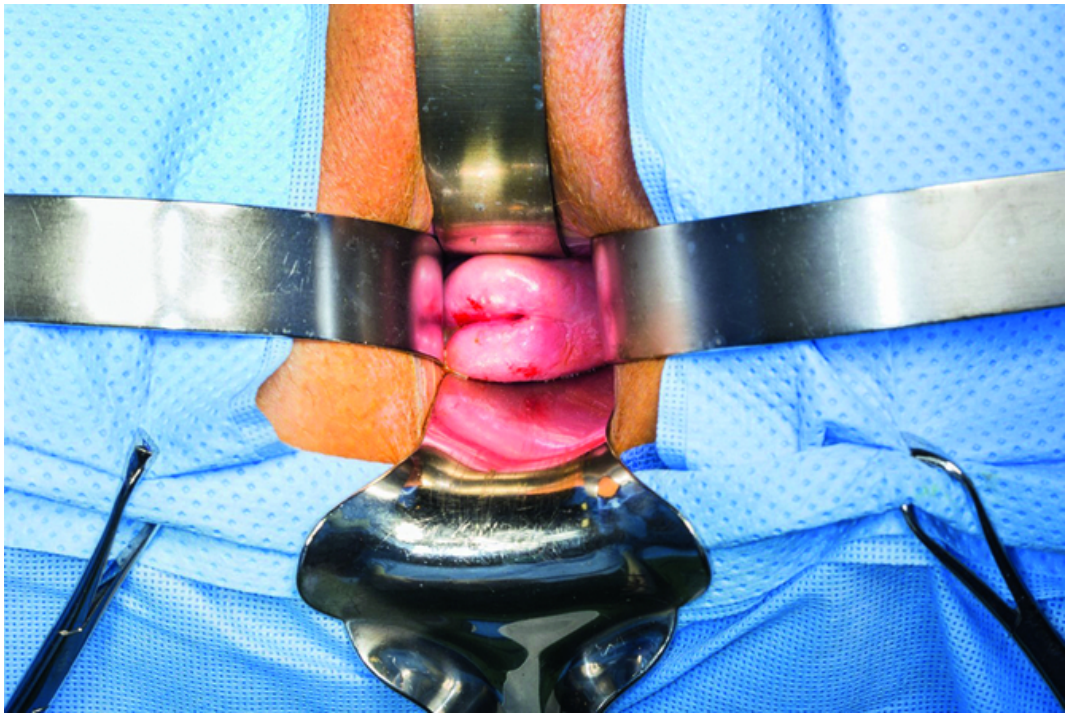


**FIGURE 22.3** Manual exposure for vaginal hysterectomy. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

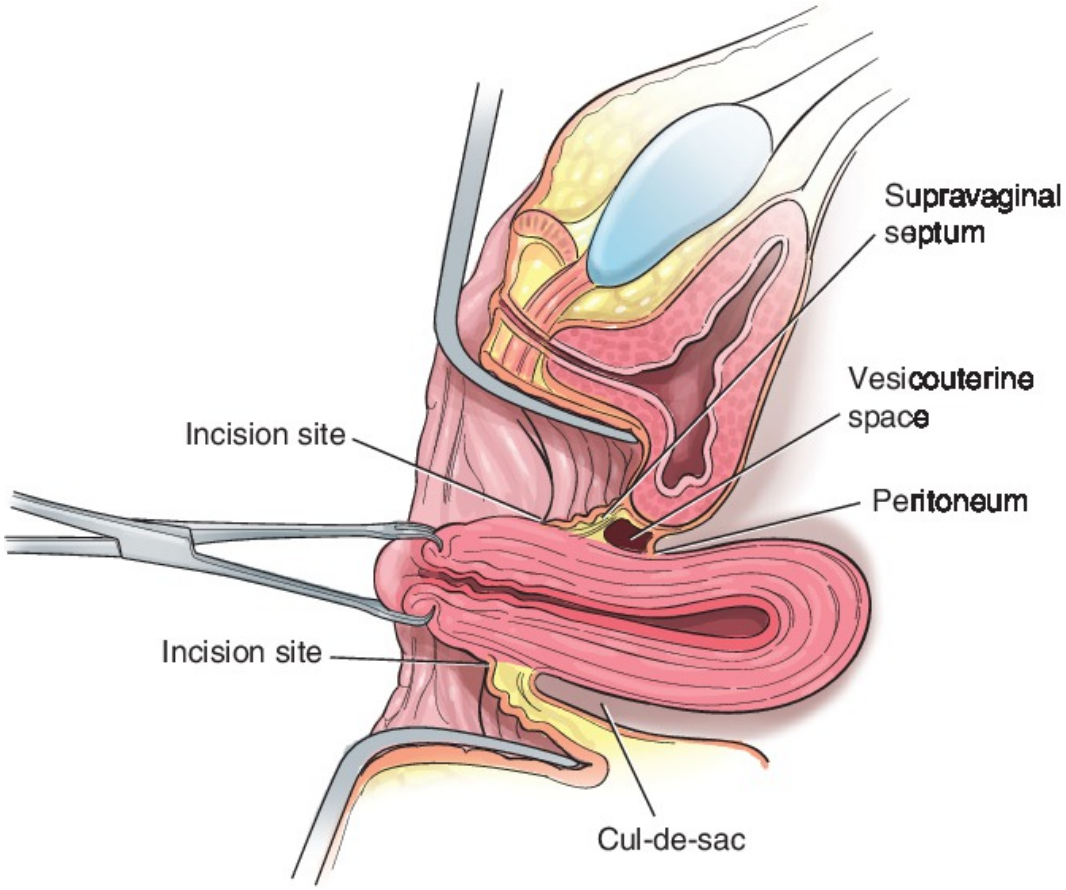
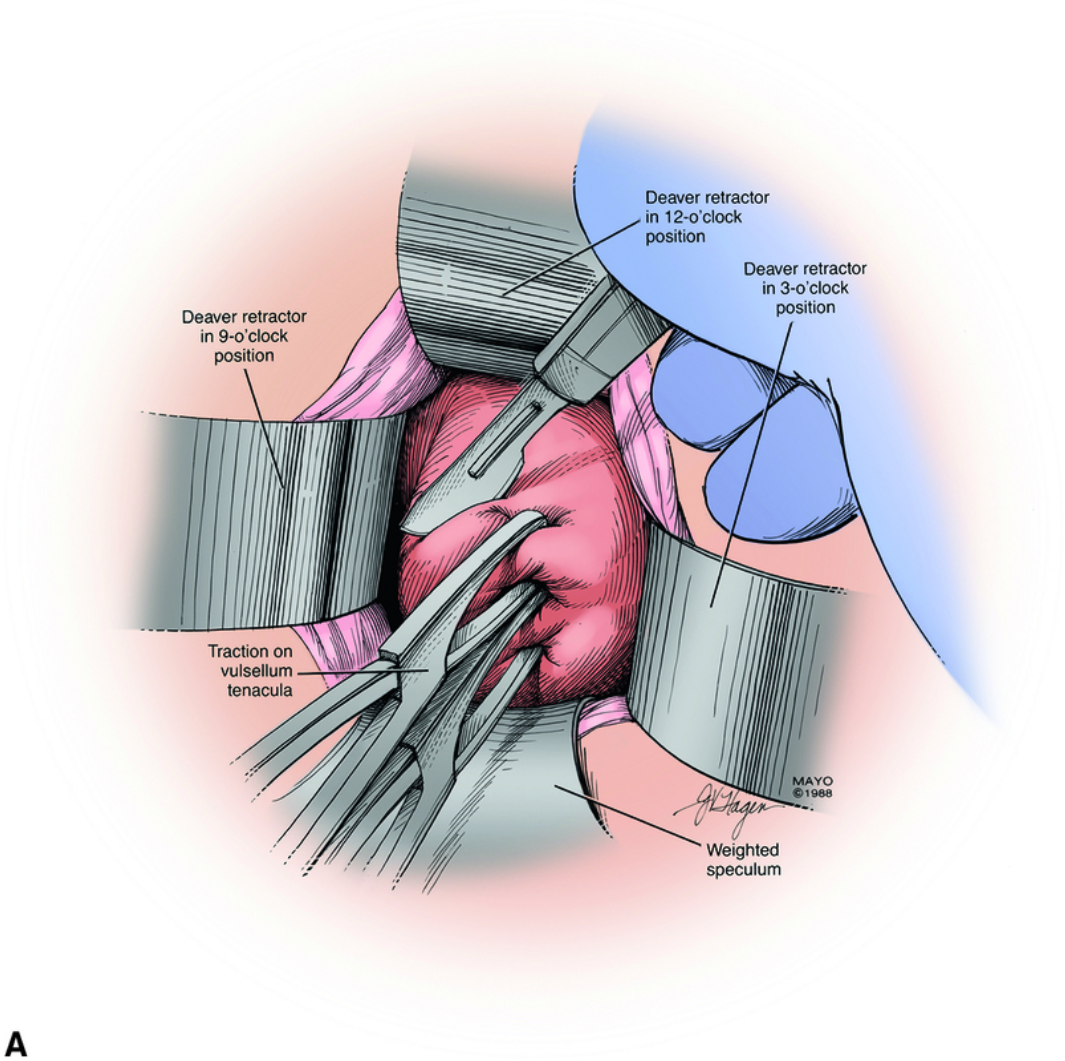


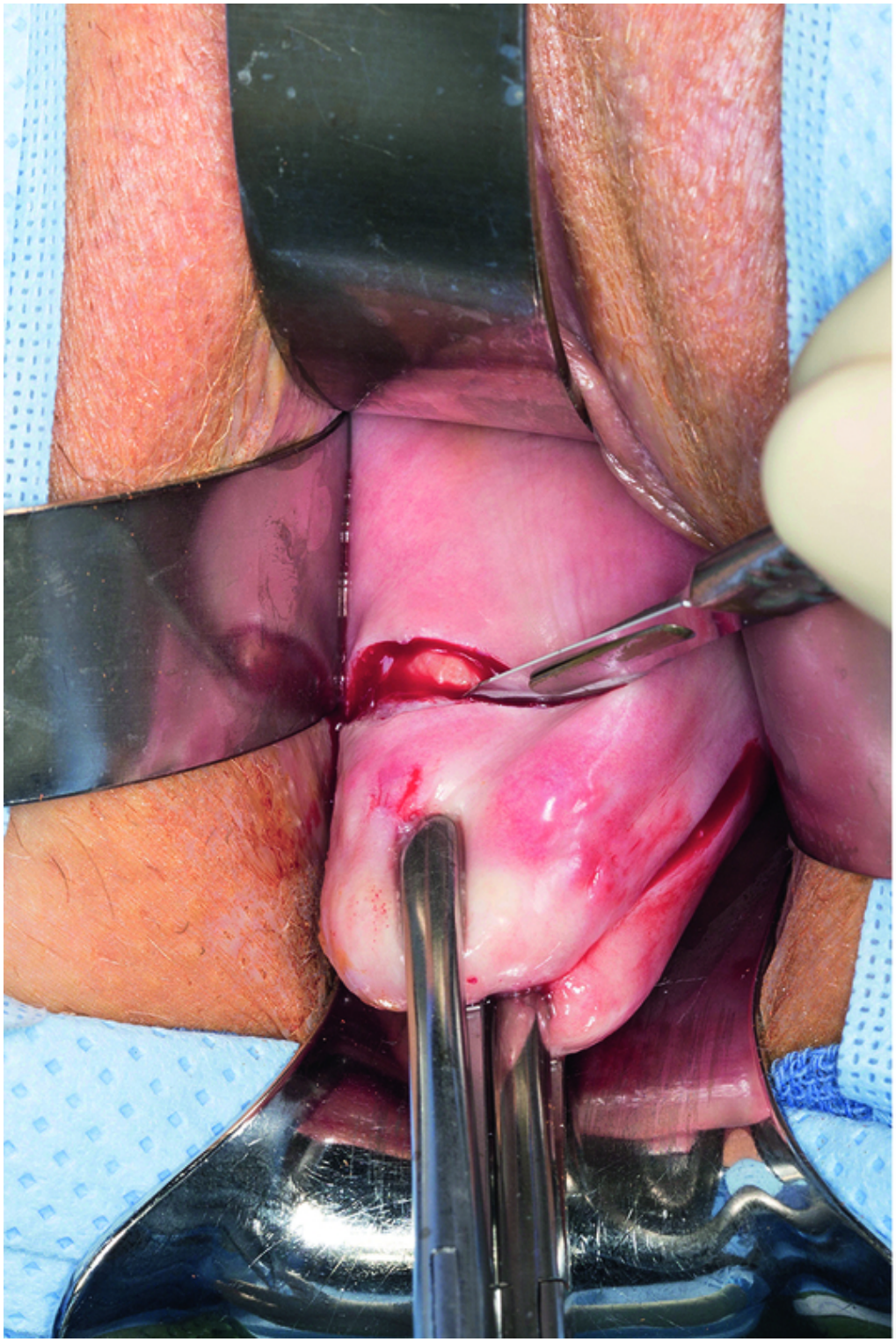

**FIGURE 22.4** Location for anterior and posterior vaginal incisions, illustrating relationship to peritoneal reflections. The correct location for the incision is often demarcated by a line where rugae begin.

The initial vaginal incisions should be made as close as possible to the anterior and posterior cul-de-sac entry sites and with the appropriate depth. If the initial incision is made too close to the external cervical os, a longer dissection of the anterior vaginal epithelium will be required to reach the anterior peritoneal reflection. However, a goal is to avoid excision of vaginal wall, leaving the vagina shortened. Likewise, if the incision is made too deep, this will result in the dissection into the cervix, which may result in significant bleeding and make the procedure more technically challenging.

Once the incision sites are identified, the vaginal epithelium is incised directly, or, if there are no medical contraindications, injected at the planned incision site with either vasopressin (10-20 units in 50 mL of saline) or 20-30 mL of 0.5% Xylocaine and 1:200 000 epinephrine. The goal of this injection is to aid in the identification of tissue planes and reduce blood loss. A small randomized controlled trial showed a significant reduction in estimated blood loss with the injection of vasoconstrictor, but a significant increase in the use of postoperative morphine when compared to the control group. A systematic review showed that vasopressin decreases blood loss by 130 mL. Then, a full-thickness, circumferential incision is made in the vaginal epithelium. This can be done sharply with a scalpel or using electrocautery (**FIG. 22.5**; **VIDEO 22.1**).


Deaver retractor in 12-o'clock position
Deaver retractor in 3-o'clock position
Deaver retractor in 9-o'clock position
Traction on vulsellum tenacula
MAYO ©1988
Weighted speculum

**A**



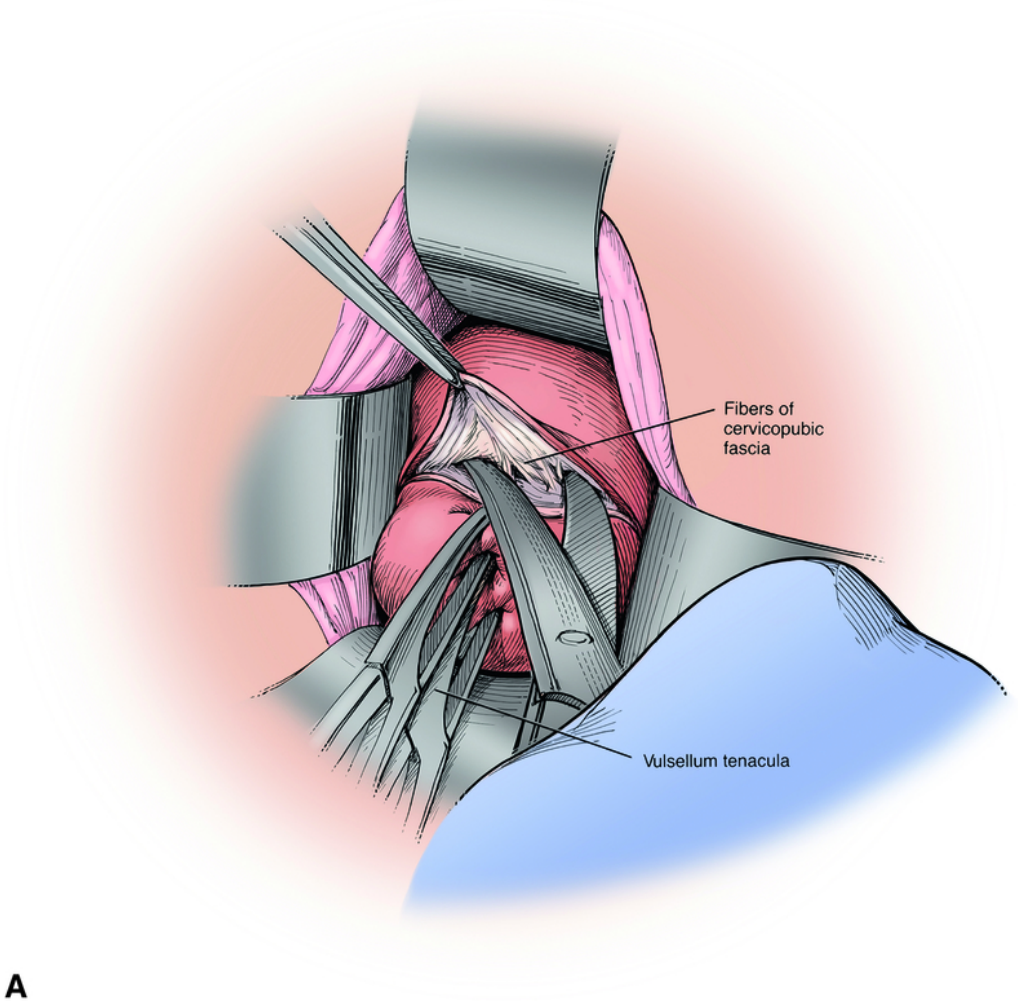
B

**FIGURE 22.5 A and B.** The anterior vaginal incision is made from 10 to 2 o'clock, through

the full thickness of the vaginal epithelium. The Deaver retractor, placed anteriorly, elevates the vaginal wall and allows it to pull away from the cervix as the incision is created. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

## *Anterior Colpotomy*

Either the anterior or posterior colpotomy can be performed as the next step. We prefer to gain anterior entry first; however, many others prefer to enter the posterior cul-de-sac initially. Anterior colpotomy will always require dissection of the vagina off the anterior cervix. This dissection is accomplished with continued downward and inferior traction of the cervix. Countertraction is typically provided by elevation of the bladder in the midline with a right-angle or Deaver retractor. Additionally, countertraction can be provided by elevating the anterior vaginal wall with Allis clamps or tissue forceps (**FIG. 22.6**).




A

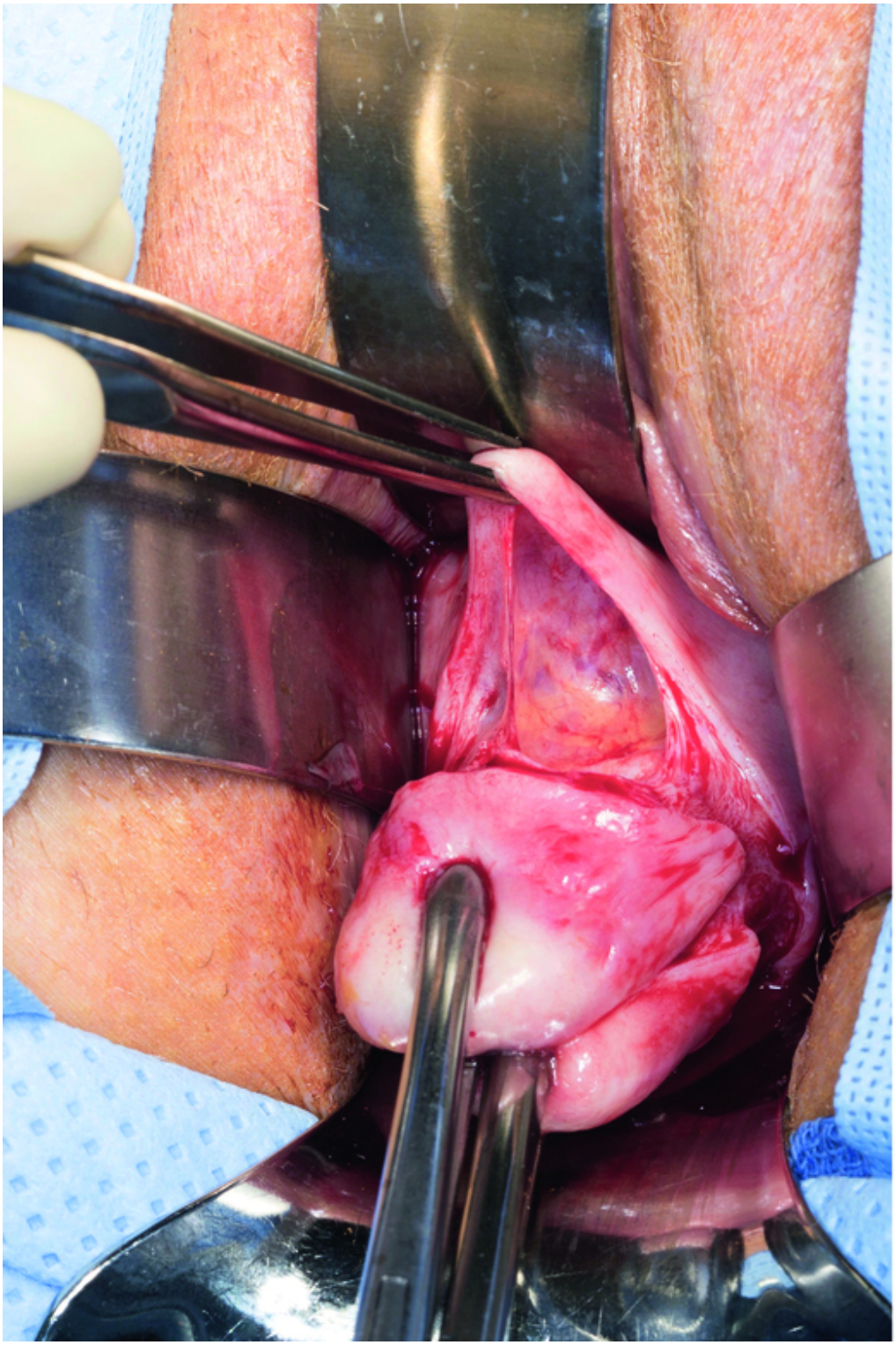



**FIGURE 22.6 A and B.** The anterior vaginal dissection continues until the anterior

peritoneum is encountered. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

If the dissection is in the proper plane, it is usually avascular and continued dissection should be relatively bloodless until the vesicouterine space is entered. If bleeding is encountered, it is usually a result of deviation of the dissection anteriorly toward the bladder, posteriorly toward the cervix, or laterally toward the bladder pillars. Often a simple adjustment of the dissecting scissors to a 45° angle while maintaining downward traction on the cervix will help to facilitate obtaining the proper plane toward the anterior peritoneal reflection. It is also important to avoid too lateral of a dissection. In most cases, the anterior peritoneal reflection can be exposed with a right-angled or Deaver retractor placed into this space to elevate the bladder. The peritoneal reflection will appear as a demarcated crescent-shaped line. It also has a characteristic “slippery” feel, allowing the surgeon’s finger to slide easily over the tissue (**FIG. 22.7**). In a small study of women undergoing vaginal hysterectomy, the median distance from the cervicovaginal incision to the anterior peritoneal reflection was 3.4 cm.

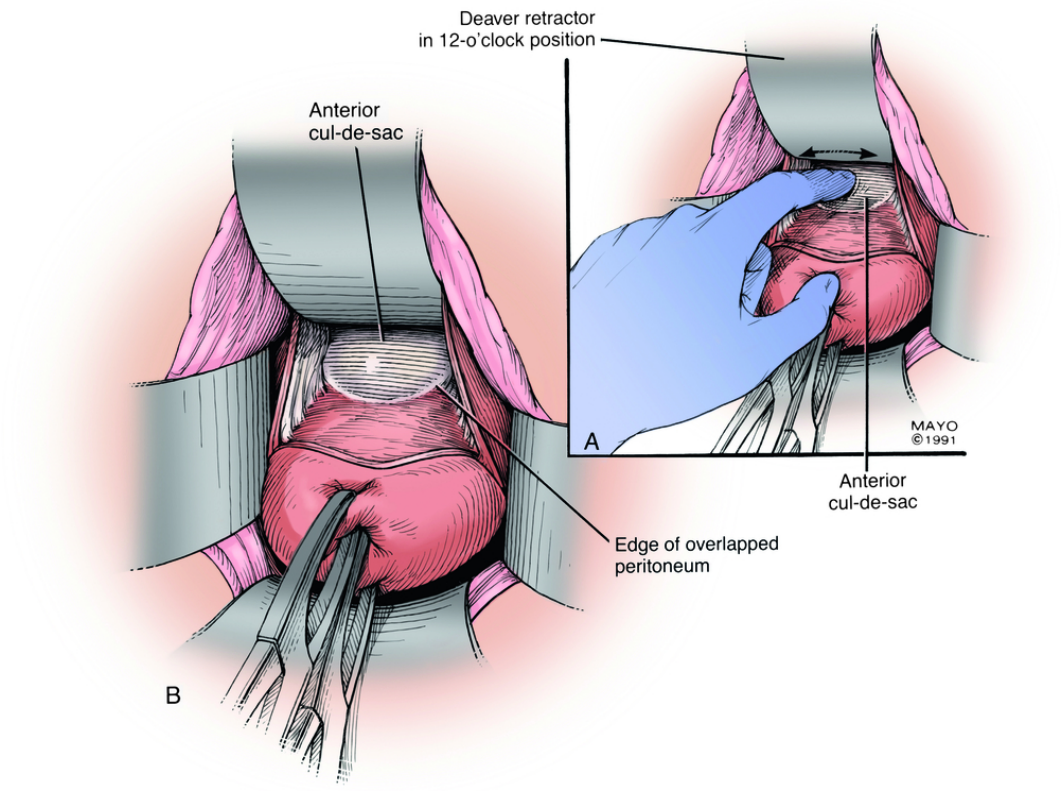
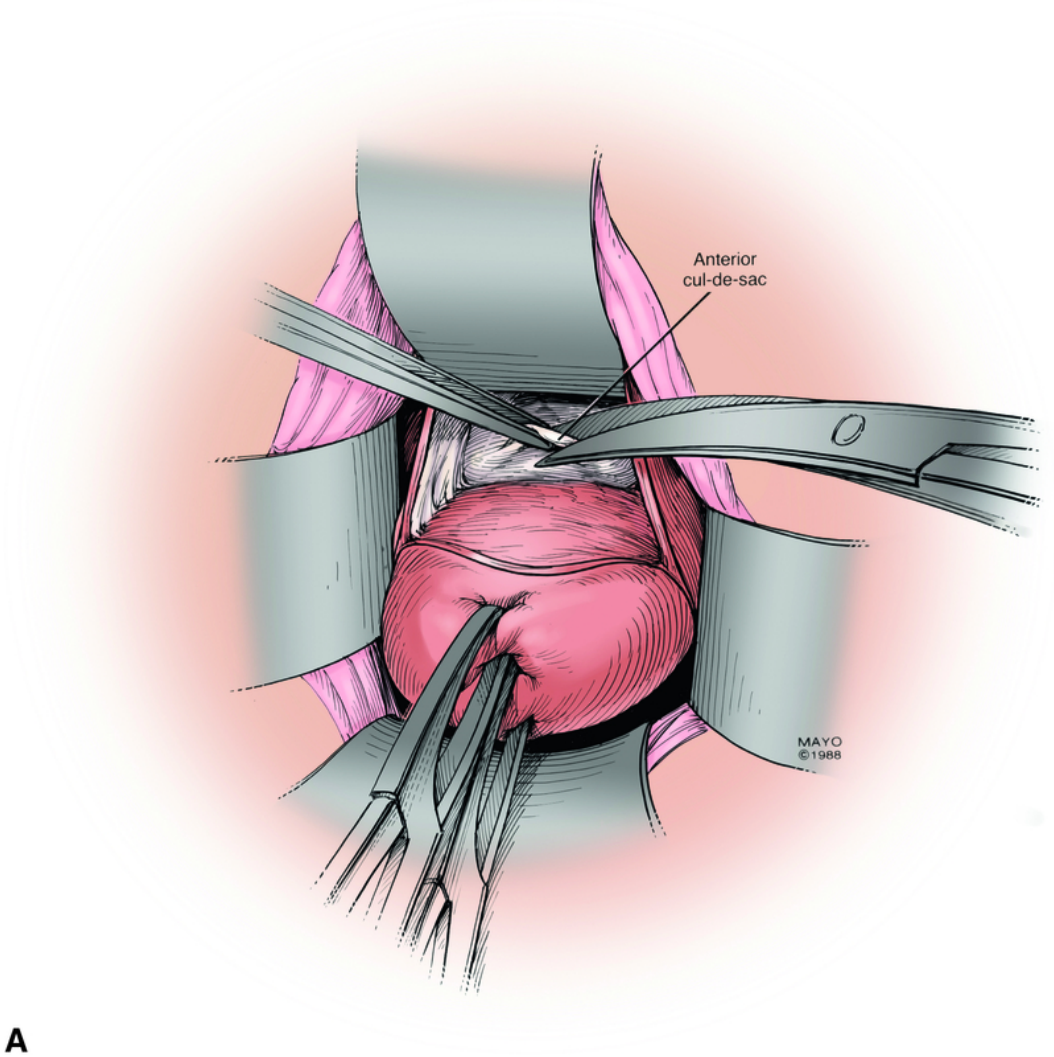



**FIGURE 22.7 A and B.** The characteristic shine and "slippery" feel of the anterior peritoneum. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

Once identified, the peritoneal reflection is grasped with toothed forceps and entered sharply using Mayo scissors (**FIG. 22.8**). The peritoneal incision is then extended sharply with scissors along the line of reflection. The incision should be wide enough to accommodate a narrow Deaver or right-angle retractor. The retractor is placed into this space to elevate and protect the bladder and allow visualization of the abdominal anatomy. In some cases, such as when the cervix is long or when descent is inadequate, the anterior colpotomy may be postponed until after the posterior colpotomy and several lateral pedicles (**VIDEO 22.2**).




**A**

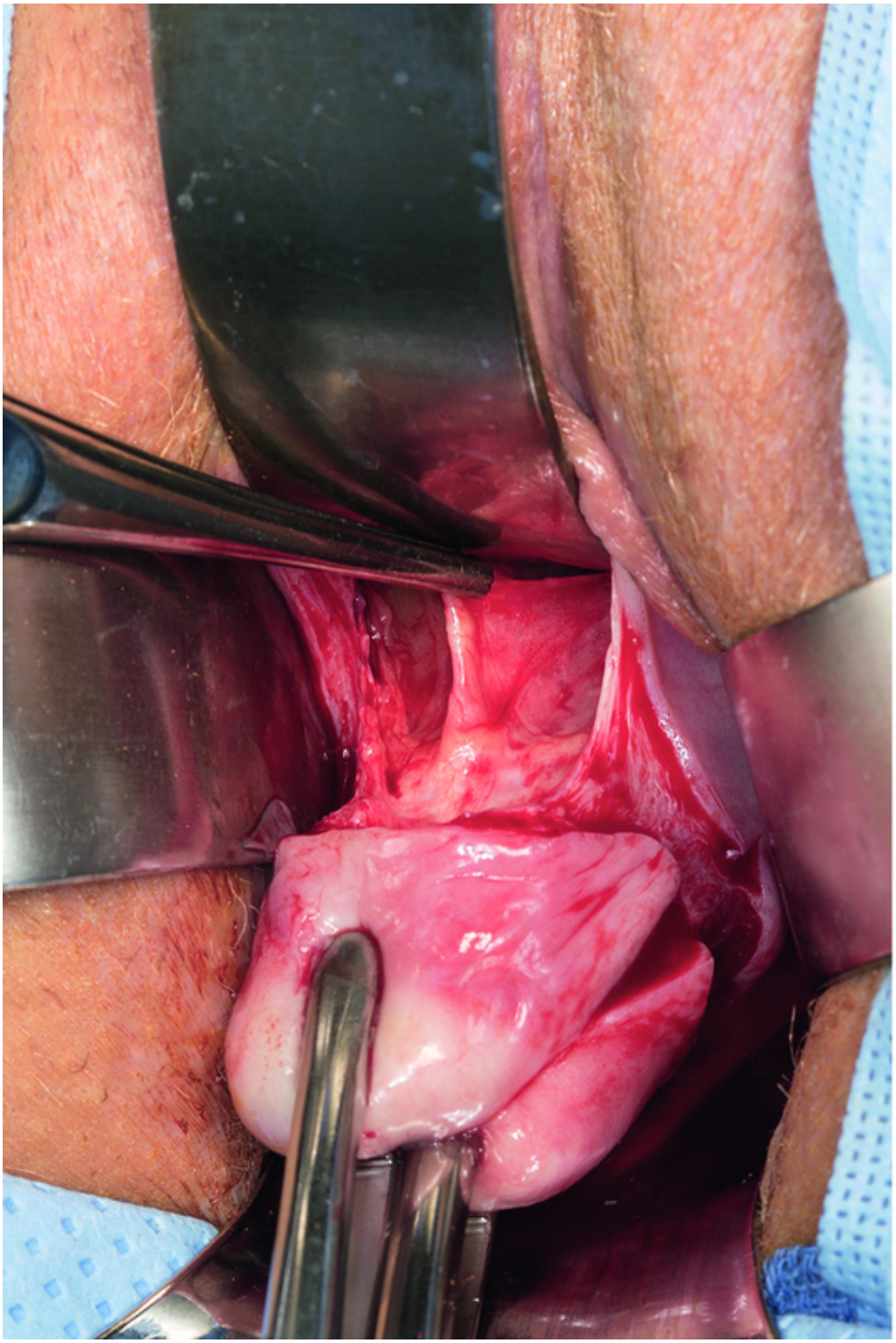


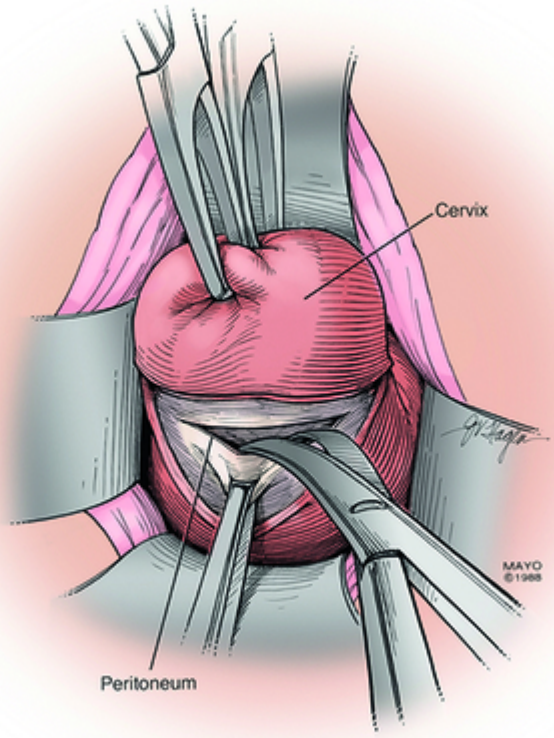

**FIGURE 22.8 A and B.** Entry into the anterior peritoneum. The anterior vagina, which has

been incised and sharply advanced off the cervix, is elevated with a retractor. The anterior colpotomy is created by grasping the peritoneal fold, pulling downward, and entering it sharply above the tissue forceps. This technique will allow the surgeon to avoid dissecting under the peritoneum in error. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

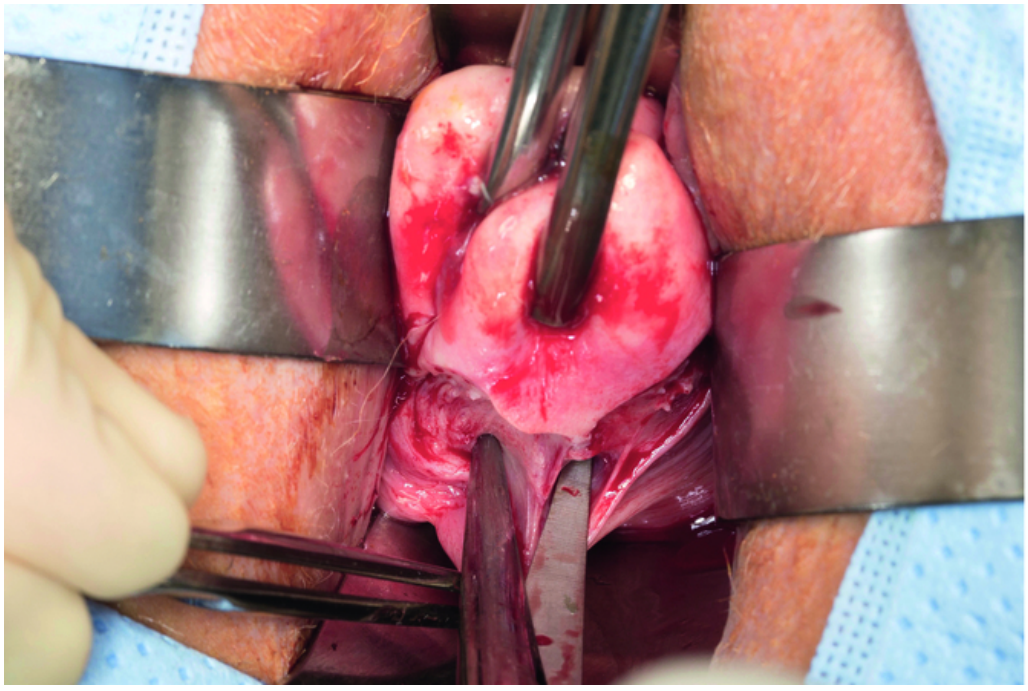
## *Posterior Colpotomy*

To make the posterior colpotomy, the posterior lip of the cervix is elevated anteriorly while downward traction is applied to the posterior edge of the vaginal incision.

Once the cul-de-sac peritoneum has been identified, it is grasped with forceps and entered with Mayo scissors (**FIG. 22.9**; **VIDEO 22.3**). After confirming that the peritoneal cavity has been entered, the Mayo scissors can be opened widely within the peritoneal incision. At this point, the surgeon should palpate the posterior uterus and adnexa to identify any unexpected masses or anatomic distortion. Some surgeons may prefer to place interrupted sutures to approximate the peritoneum to the vaginal cuff, which may aid in hemostasis. In some cases, these sutures may also help define the peritoneum at the time of vaginal cuff closure. However, this is typically an unnecessary step and may potentially narrow the opening to the peritoneum.




A

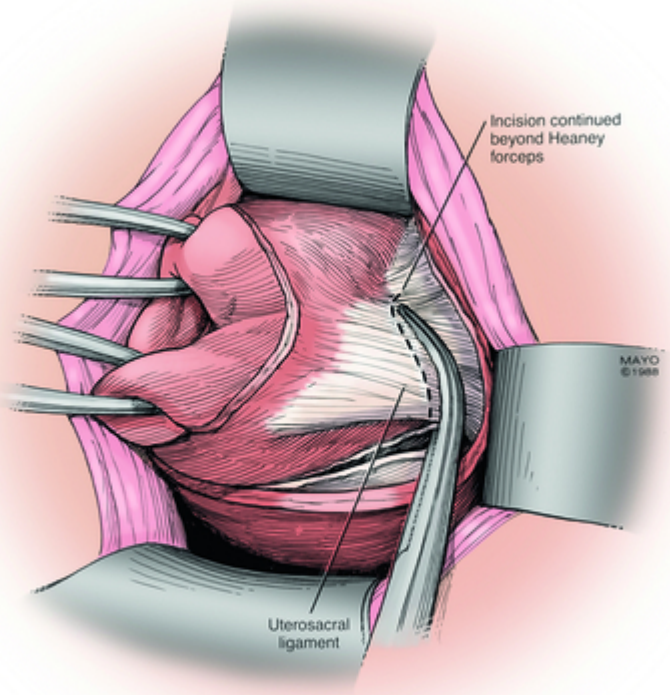


B

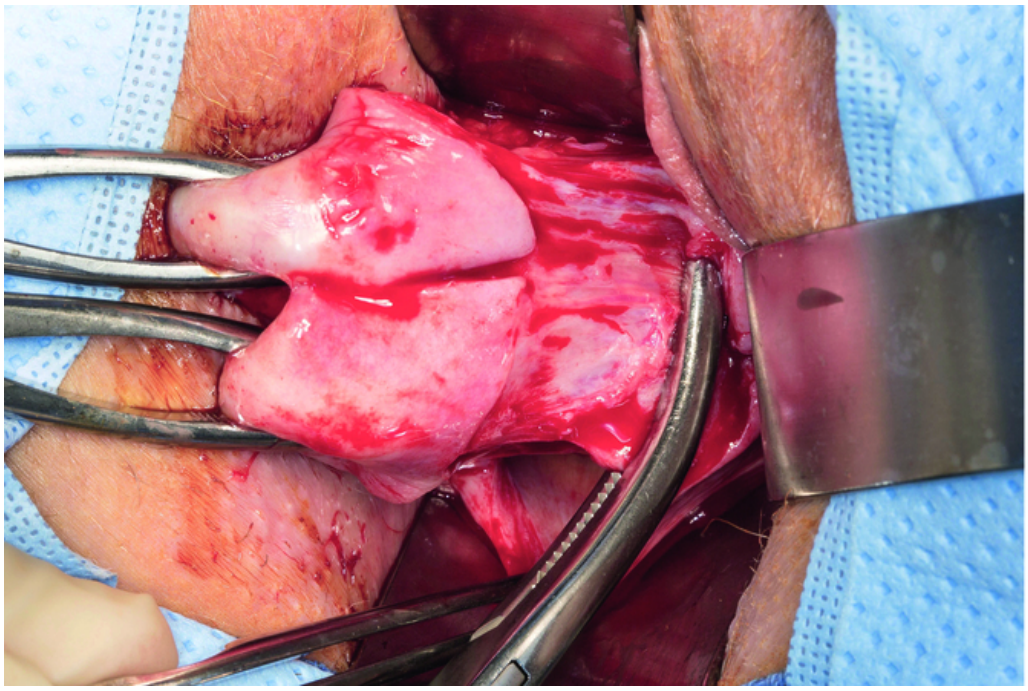
**FIGURE 22.9 A and B.** Posterior colpotomy: the cervix is retracted anteriorly while the peritoneum is exposed. The peritoneal fold is grasped with a tissue forceps and entered with scissors. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

## *Separate Ligamentous Attachments*

Next, the uterosacral ligaments are identified. With continued downward traction on the cervix toward the introitus and with anterior and lateral side wall retraction, a Heaney clamp is placed on the uterosacral ligament. The clamp should be placed perpendicular to the axis of the uterus making sure to incorporate the posterior peritoneum (**FIG. 22.10**). Traction on the cervix and placement of the clamp immediately adjacent to the cervix will minimize the risk of ureteral injury. Next, the ligament is cut with scissors. The pedicle is then suture ligated using a Heaney transfixation (or similar) technique (**FIG. 22.11**). The uterosacral ligament pedicle can be tagged or immediately transfixed to the posterolateral vaginal epithelium. We prefer to tag this to help facilitate the location and inspection of all the pedicles at the end of the procedure and for use in an apical support procedure at the end of the case.


Incision continued
beyond Heaney
forceps
MAYO
©1988
Uterosacral
ligament

A



B

**FIGURE 22.10 A and B.** The uterosacral ligament is clamped, cut, and ligated. Note that the tip of the clamp closely approximates the cervix. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

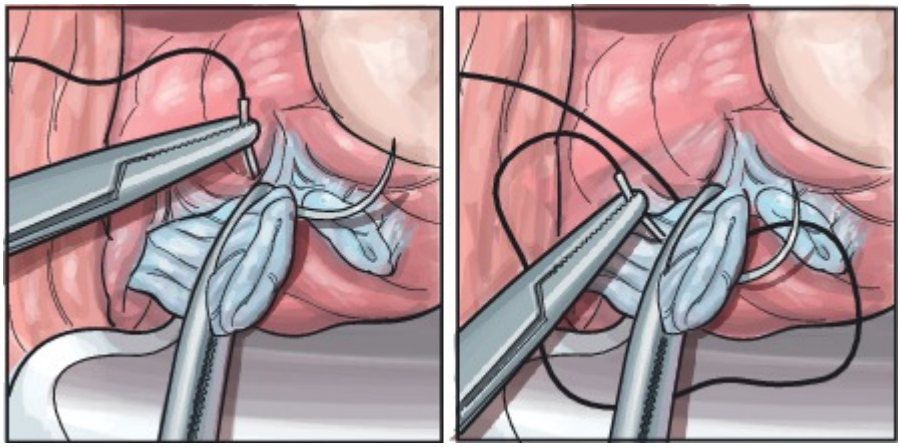
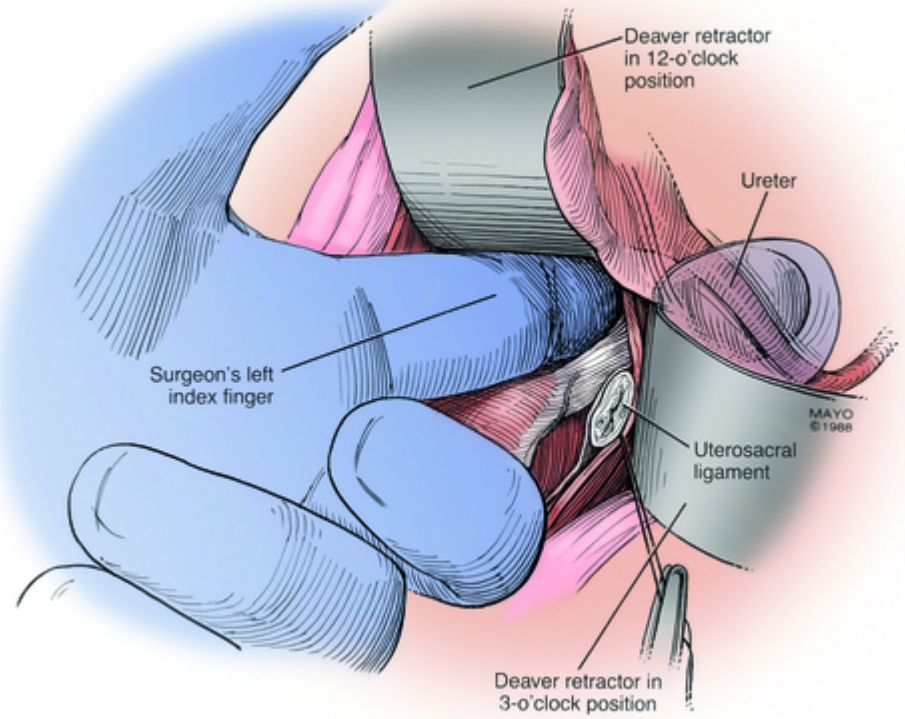


**FIGURE 22.11** A Heaney transfixion suture is placed to ligate the pedicle.

## *Ureteral Palpation*

Knowing the location of the ureter will decrease the risk of compromise during vaginal hysterectomy. To palpate the left ureter, right-sided countertraction is applied to the uterus and a narrow Deaver retractor placed at the 2 o'clock position in the vaginal canal. The left index finger of the surgeon is placed intraperitoneally through the anterior cul-de-sac and withdrawn while pressing against the Deaver. Ureteral location is noted by a characteristic snap of the ureter (**FIG. 22.12**).


Deaver retractor in 12-o'clock position
Ureter
Surgeon's left index finger
MAYO ©1988
Uterosacral ligament
Deaver retractor in 3-o'clock position

A

B

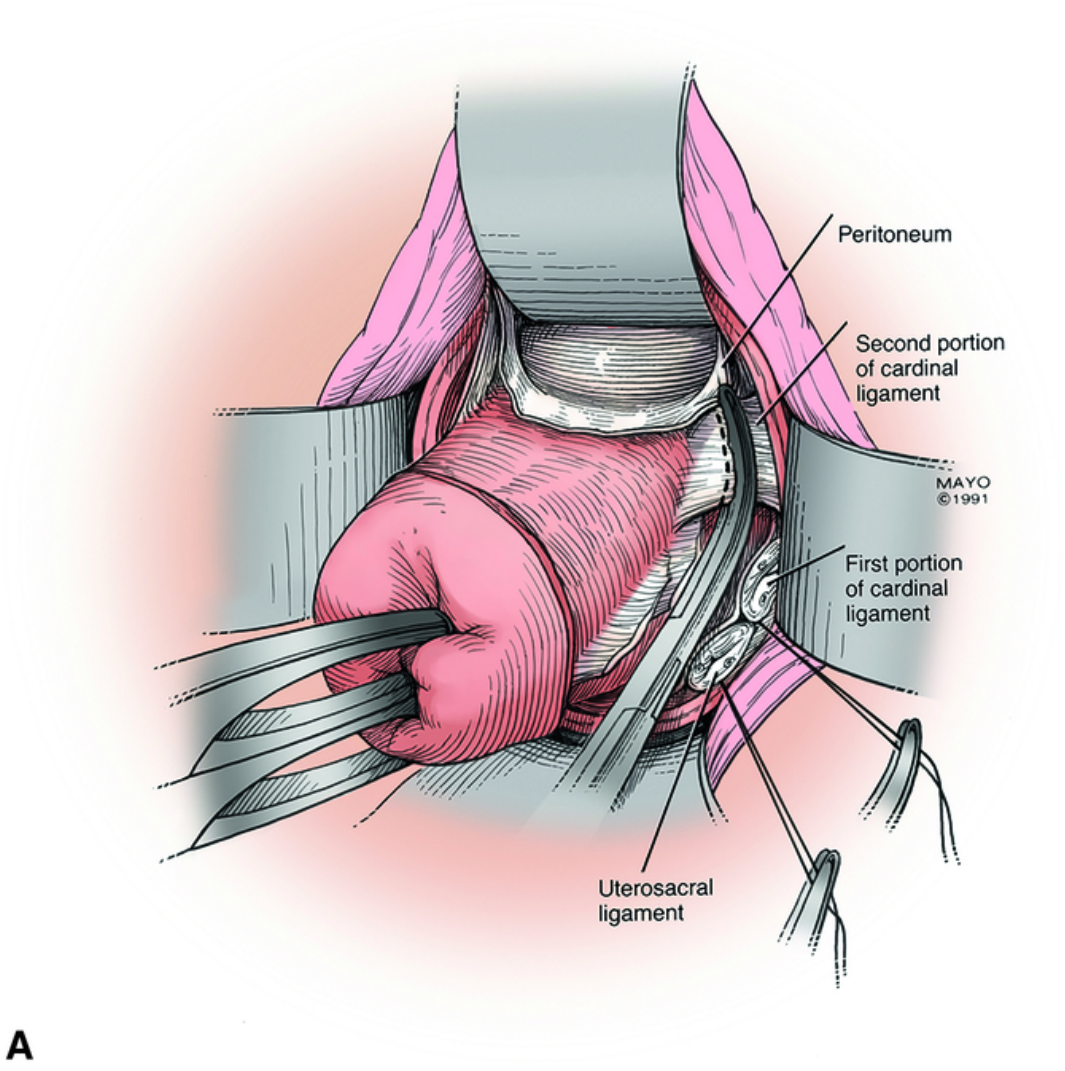
**FIGURE 22.12 A and B.** Transvaginal palpation of the left ureter. Right-sided countertraction is applied to the uterus and a narrow Deaver retractor placed at the 2 o'clock position in the vaginal canal. The left index finger of the surgeon is placed intraperitoneally through the anterior cul-de-sac and withdrawn while pressing against the Deaver. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

The cardinal ligament is then obtained in a similar fashion making sure that the clamp is placed medial to the prior pedicle. It is important to maintain downward traction on the cervix when securing the uterosacral and cardinal ligaments. This technique, in addition to retracting the anterior vagina and bladder wall, will displace the ureters laterally and superiorly to minimize the risk of ureteral injury.

## *Secure Blood Supply*

Once entry into both the anterior and posterior peritoneum is confirmed and the uterosacral and cardinal ligaments are clamped and cut, the uterine artery is divided. This is typically at the junction of the cervix and uterine fundus, at the level of the internal os. To clamp the uterine artery pedicle, the Heaney clamp is opened wide and initially placed partially across the cervix, incorporating both the anterior and posterior peritoneum and the uterine vessels within the clamp. As the clamp is closed, it should slide off the cervix or lower uterine corpus before clamping down. To make sure that all the collateral vasculature is within the clamp, as the clamp is closed, the handle is rotated laterally, leaving the tip of the clamp perpendicular to the cervix. While some surgeons doubly clamp (and doubly ligate)

the uterine artery pedicle, a single-clamp technique is usually preferred to reduce the risk of ureteral injury (**FIG. 22.13**).

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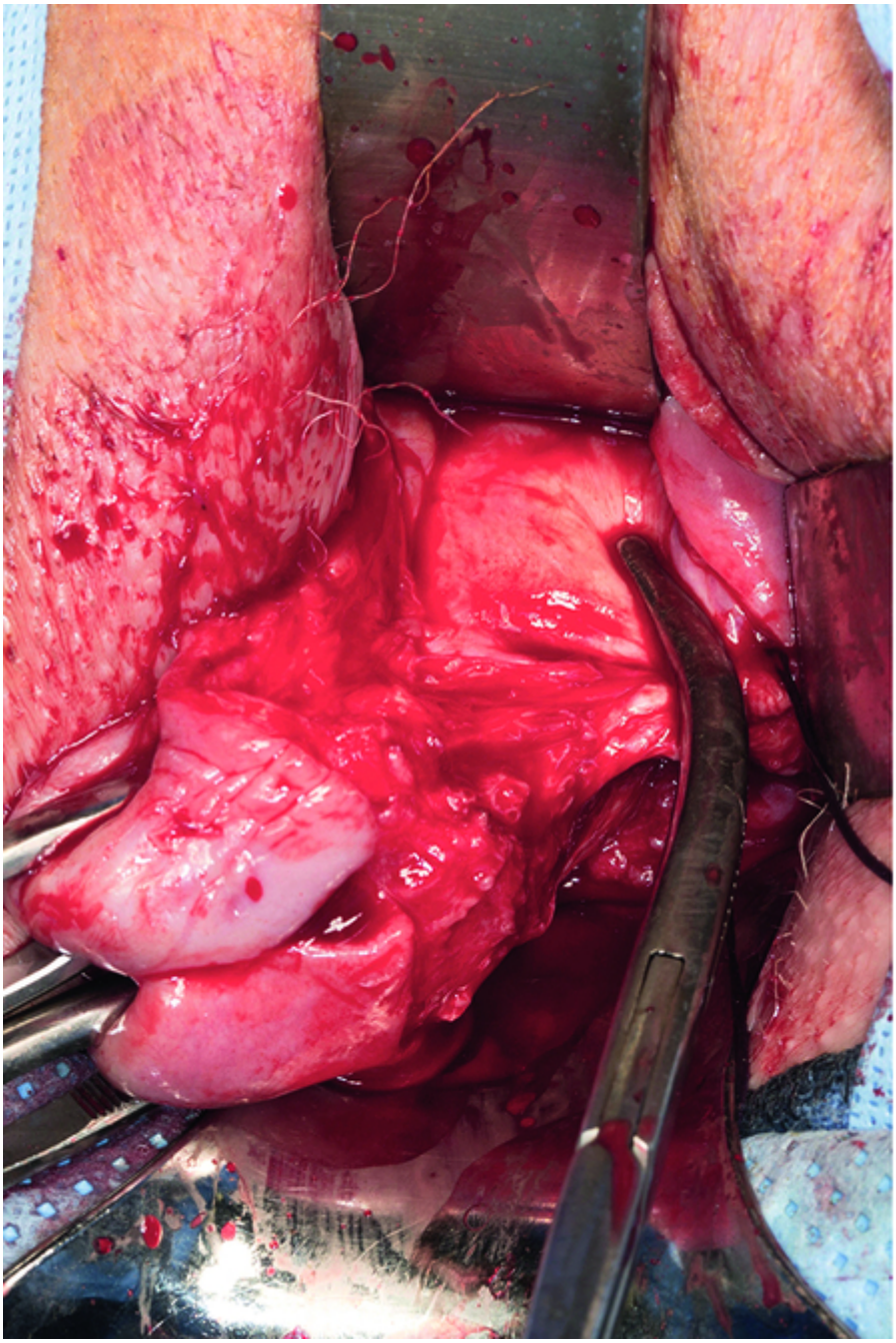


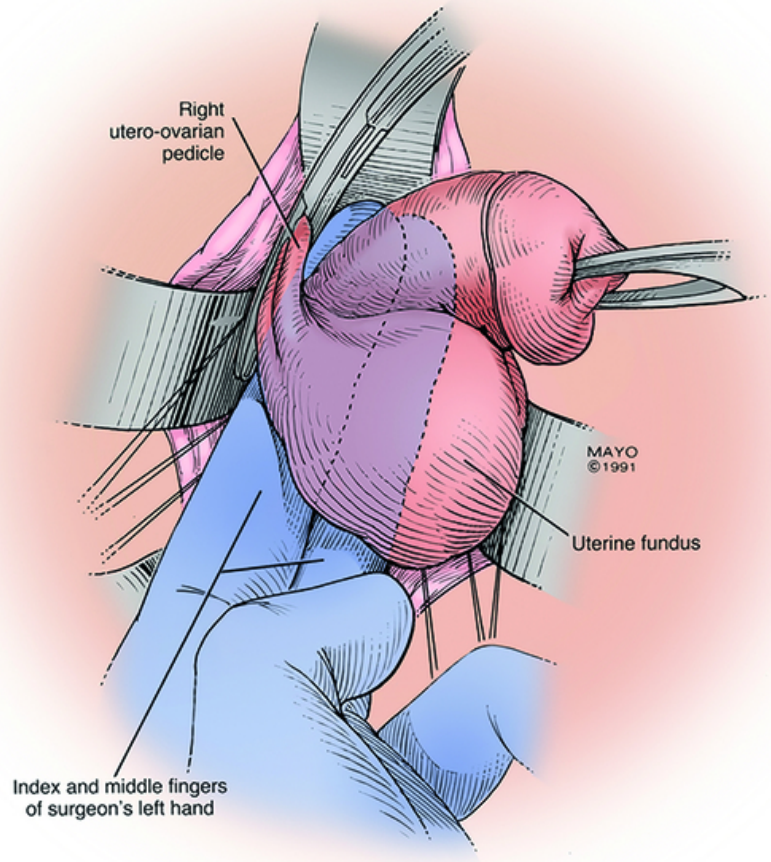

**FIGURE 22.13 A and B.** Clamping of the uterine vasculature with attention to direct the tips of the Heaney clamp toward the midline. (Used with permission of Mayo Foundation for

Medical Education and Research, all rights reserved.)

It is important to make certain that all branches of the uterine vasculature have been ligated before proceeding with the remainder of the procedure. Additional clamping and ligation of the broad ligament may be necessary, especially in larger uteri. Each clamp should be placed medial to the previous pedicle with the heel of the clamp just adjacent to this pedicle. This maneuver helps to eliminate unsecured vascular spaces between the pedicles (which could potentially result in areas of bleeding).

Once the uterine vessels have been secured bilaterally and enough broad ligament tissue has been transected to allow full mobility of the uterus, the fundus can be rotated posteriorly, through the posterior colpotomy and into the vaginal canal. This is accomplished by first grasping the fundus with a tenaculum or Lahey thyroid clamp and with gentle traction in a successive fashion, the uterine fundus is delivered posteriorly through the posterior colpotomy. This step is not required but typically facilitates the ligation of the utero-ovarian pedicles.

Next, the surgeon's index and middle fingers are used to identify the utero-ovarian ligament. With traction on the uterus, the surgeon's fingers are positioned posteriorly to isolate the right utero-ovarian pedicle and protect the bowel. A Heaney clamp is placed across the pedicle, from anterior to posterior, securing the pedicle (**FIG. 22.14**). The pedicle is transected using scissors. We prefer to leave this pedicle clamped and ligate it once the left utero-ovarian ligament is transected as the surgeon is afforded more space once the uterus has been removed. Next, the left utero-ovarian pedicle is clamped, transected and this accomplishes the removal of the uterus, which is visually inspected and handed off the field (**FIG. 22.15**).


Right
utero-ovarian
pedicle
MAYO
©1991
Uterine fundus
Index and middle fingers
of surgeon's left hand

**A**

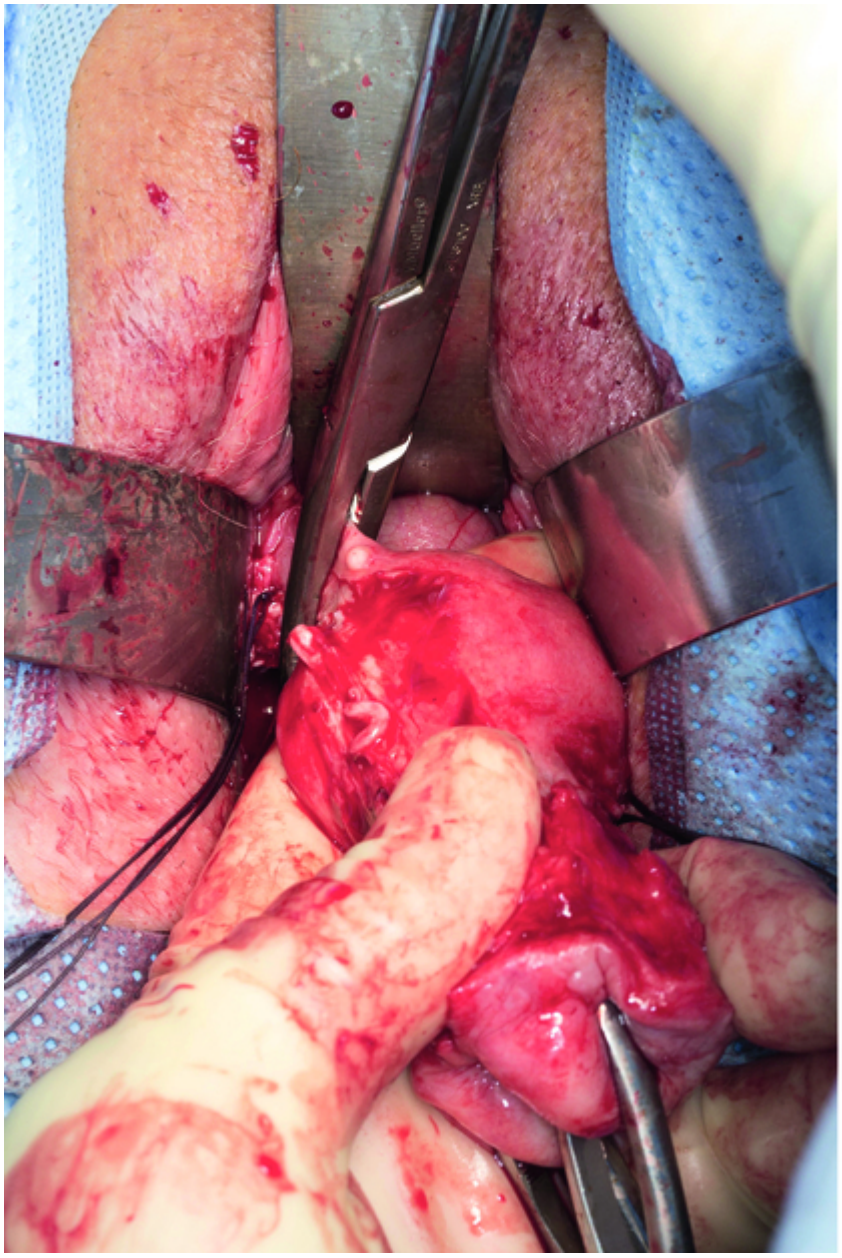
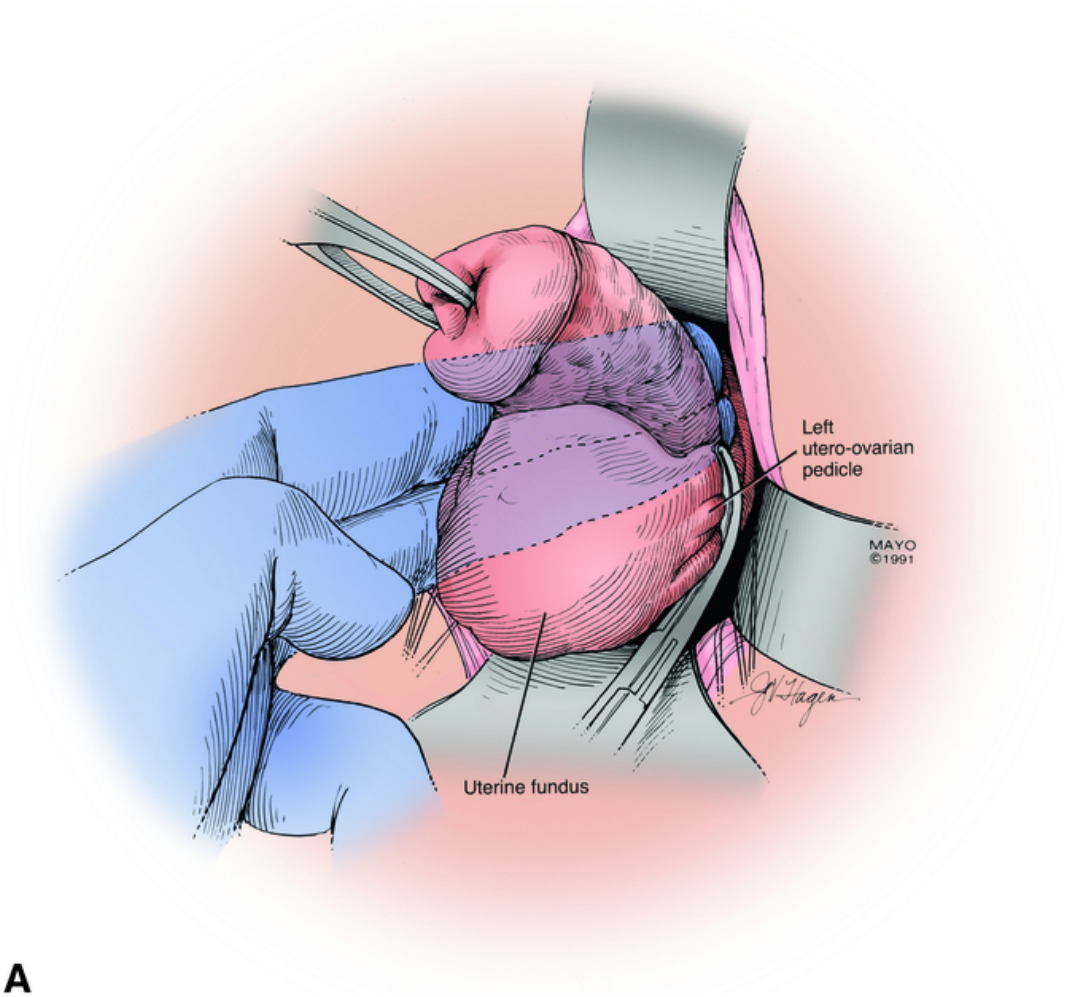



**FIGURE 22.14 A and B.** The surgeon's fingers are used to isolate the right utero-ovarian pedicle and deflect any bowel away as the pedicle is clamped and in an anterior to posterior direction. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

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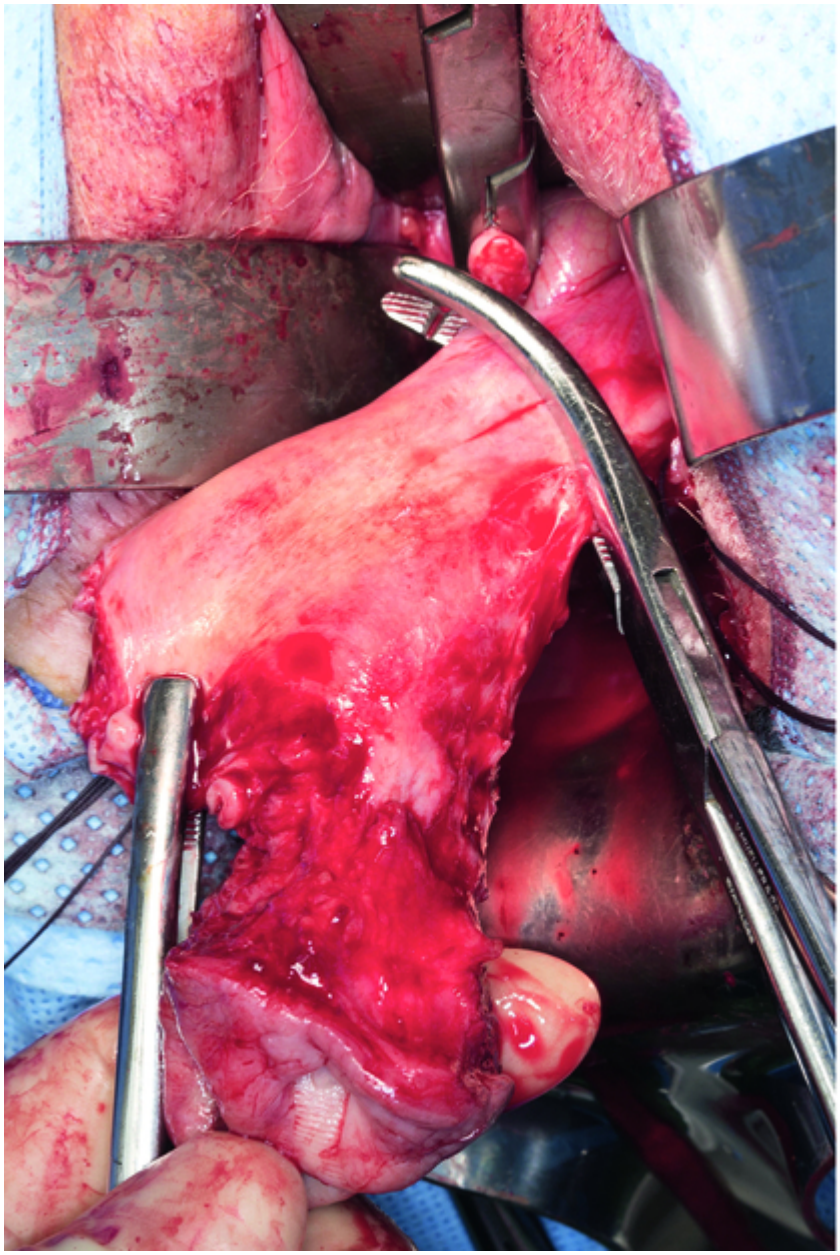



**FIGURE 22.15 A and B.** Traction on the uterus allows for visualization and clamping of the left utero-ovarian pedicle. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

A single transfixation suture can be used to secure these pedicles. Similar to other steps, this pedicle can be doubly clamped (and doubly ligated). If double-ligation is planned, a free tie (or tie on a passer) is placed around the pedicle; as it is tied down, the lateral clamp is removed. Next, a transfixion suture is placed (distal to the tie), and the pedicle is suture ligated. As this ligature is tied and the second Heaney clamp is removed, it may be helpful for the assistant to grasp the tip of the pedicle to stabilize it, as the surgeon ties the knots. We prefer to tag all pedicles to aid in the evaluation of hemostasis and facilitate the removal of the adnexa if desired (**FIG. 22.16**).

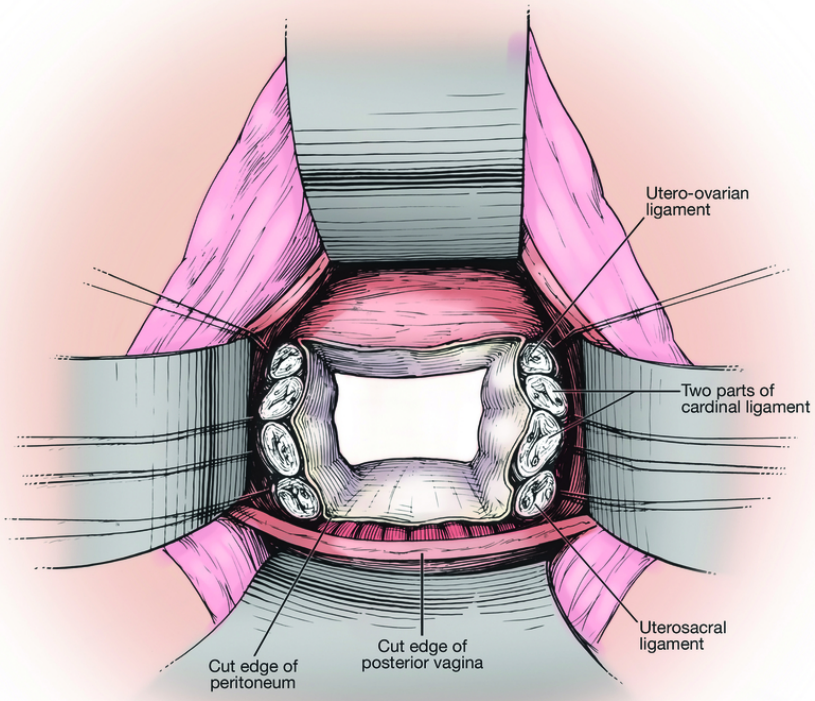


**FIGURE 22.16** All pedicles are tagged and can be used to assist with obtaining visualization for hemostasis. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

## *Evaluation of Hemostasis*

Once the uterus has been removed, it is important to evaluate each pedicle to confirm hemostasis. Even if the plan is to remove the adnexa during the surgery, inspecting for bleeding should occur at this point. Assessment of hemostasis is performed in a systematic fashion: each pedicle can be evaluated, starting at the utero-ovarian pedicle within the peritoneal cavity and proceeding in a clockwise manner. In some cases, the pedicles are best visualized with a combination of traction on the utero-ovarian and uterosacral pedicles and eversion of the pedicles with a right-angle retractor along the lateral vaginal wall. When active bleeding is noted during this assessment, most often it is discovered between the uterine artery and utero-ovarian pedicles (in a section of the broad ligament where anastomosis of the ovarian and uterine vessels can occur). Placement of a long right-angle clamp or Kelly clamp at the site of bleeding without undue traction may be followed by electrocautery, a helical suture or a figure-of-8 suture (**FIG. 22.17**). The surgeon should be mindful to visualize the bleeding site directly to avoid blind suture placement and should be careful to control the depth of suture placement, given the proximity of the ureters.

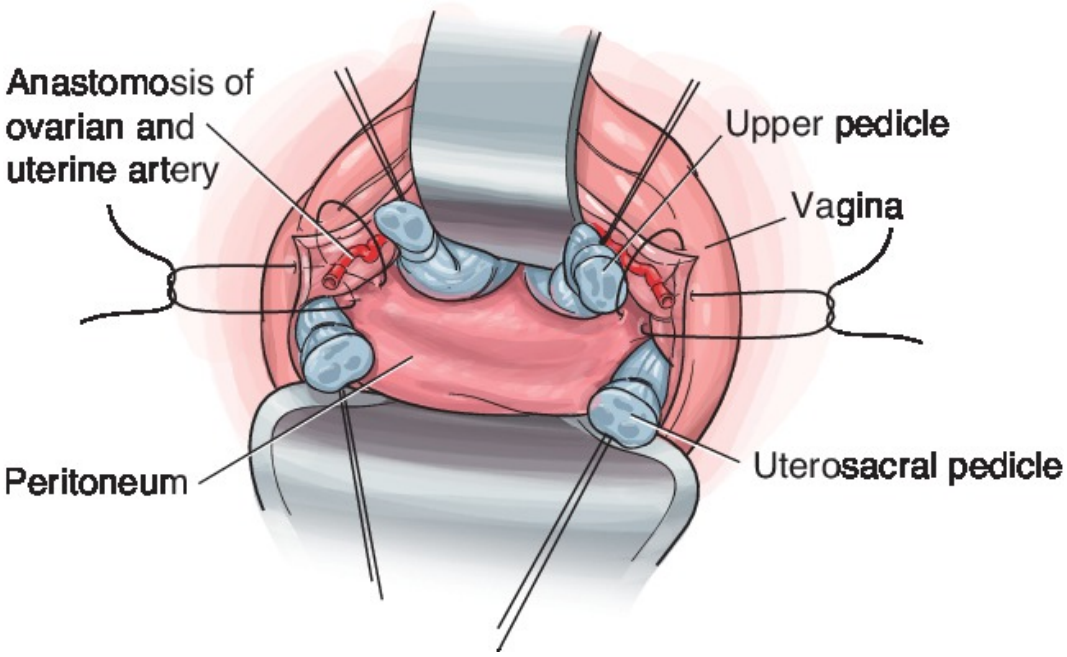



**FIGURE 22.17** The most common source of bleeding after removal of the uterus is the anastomosis between uterine and ovarian arteries. Suture placed through the lateral vagina into the lateral peritoneum in a figure-of-8 fashion and tied resolves most, if not all, bleeding from this area.

The posterior vaginal epithelium should be thoroughly inspected as the posterior cuff is often the source of bleeding. This is due to the separation of the vagina and the peritoneal edge. To see the posterior vaginal edge, the surgeon may need to retract the weighted speculum from the peritoneal cavity to reveal the posterior edge. If active bleeding is noted, hemostasis can be achieved with absorbable suture or electrocautery.

It is important to note that the hysterectomy can also be performed using an electrosurgical vessel-sealing device instead of the traditional suture ligation method to secure pedicles. A systematic review demonstrated that tissue-sealing devices

decrease blood loss by 44 cc and operative time by 15 minutes but with uncertain complication implications. The surgeon should be attentive to heat generated by such devices to ensure that the surrounding tissue and vulvar skin are protected from iatrogenic thermal injuries. Bipolar vessel-sealing devices are preferred to ultrasonic vessel-sealing devices as the ultrasonic instruments are unable to achieve hemostasis on vessels larger than 4-5 mm. In addition to the cost of the vessel-sealing device, when used, a disadvantage is the pedicles (including the uterosacral ligaments) cannot be tagged for later use during the case.

## *Closing the Vaginal Cuff*

Before reapproximating the vaginal epithelium, a McCall culdoplasty (Chapter 30) may be performed to reduce the risk of future enterocele and vaginal vault prolapse. The incidence of enterocele after hysterectomy can range between 0.1% and 16%. Performing a vaginal suspension at the time of vaginal hysterectomy may reduce the risk of future prolapse. Placing a vaginal pack in the pelvis to retract the bowel out of the way can be helpful when performing an intraperitoneal apical suspension. We close the peritoneum in a purse-string fashion prior to vaginal cuff closure. The vaginal pack should be removed prior to peritoneal closure. Next, the vaginal cuff is closed, either with a series of interrupted sutures or in a running fashion. This is based on the preference of the surgeon. A running locking stitch may be required when there is active bleeding noted from the edge of the vaginal epithelium since this would aid in hemostasis. Regardless of surgeon preference, these sutures should be placed through the full thickness of the vaginal epithelium and incorporate the ligamentous pedicles of the uterus. Care should be taken to ensure that the bladder is not inadvertently entered (**VIDEO 22.4**).

## *Cystoscopy*

Universal cystoscopy following vaginal hysterectomy significantly increases recognition of both bladder and ureteral injury. Although

some surgeons choose to perform cystoscopy only after more difficult vaginal hysterectomy cases (difficult anterior dissection), and while cystoscopy may not identify all injuries, it is a low-risk procedure that may be beneficial in surgeries associated with a high rate (1%-2%) of lower urinary tract injury. We prefer to perform cystoscopy following all vaginal hysterectomy procedures.

Ureteral injuries most commonly occur at the level of the uterine artery (80%), the infundibulopelvic ligament, and at the vaginal cuff. Early detection and repair of bladder or ureteral injury is preferable to avoid potentially long-term postoperative complications, such as fistula formation and loss of renal function. Early detection and repair of urinary tract injury may also reduce medicolegal risk. If an apical suspension procedure is performed at the time of vaginal hysterectomy, cystoscopy should be performed to ensure no ureteral injury occurred as a result of the suspension procedure itself.

Cystoscopic assessment of ureteral patency can be assessed by one of several methodologies. One preferred method, given its effectiveness and low cost, is to dye the urine via the intravenous injection 10% preparation of sodium fluorescein at 0.25-1 mL. Within minutes of intravenous injection, the urine will be dyed with a “brilliant” yellow color. Similarly, intravenous indigo carmine (40 mg/5 mL) has low cost and will turn the urine blue for easy visualization. Visualization of efflux of the dyed urine from each ureteral orifice demonstrates ureteral patency. An alternative option is the preoperative oral administration of a single tablet of Pyridium 200 mg. If this medication is ingested within an hour prior to surgery, the urine will be dyed with a yellow ochre color, typically for up to 4-5 hours. Finally, the use of sterile water and a 10% dextrose solution as the cystoscopic distension mediums offers a contrast in viscosity between the urine and the cystoscopy fluid, which may enhance the ability to detect ureteral efflux. While comparison of these methods, including two randomized controlled trials, has not yielded a “best practice,” all have concluded that the various options were superior to not using any of the techniques.

# SPECIAL CONSIDERATIONS

There are some situations that can make the vaginal approach to hysterectomy more technically challenging. Four challenges are addressed here: difficult anterior colpotomy, cervical elongation, enlarged uterus, and minimal descensus. These conditions could possibly lead prematurely to a conversion to an abdominal approach (laparoscopic or open), although converting is not considered a complication of the procedure. Patients are counseled in advance that this is a potential known risk of the procedure and, therefore, not entirely unexpected if it does occur. Ultimately, the decision to change the approach to surgery is the discretion of the surgeon. Such a decision should be made expeditiously especially in the setting of uncontrollable hemorrhage (which may occur during morcellation or if an avulsed vascular pedicle cannot be secured).

# Difficult Anterior Colpotomy

The difficult anterior colpotomy is one of the most common challenges that one may experience when performing a vaginal hysterectomy. Difficulty with this step of the surgery may be due to several factors including distorted anatomical planes because of prior abdominal or pelvic surgery (including cesarean section), normal anatomical variation (eg, cervical elongation), and surgical technique. A cesarean section or lower myomectomy scar distorts the anatomy by occluding the vesicouterine space between the scar and the urinary bladder.

Several surgical techniques, such as infiltration of the vasoconstrictive agent prior to the vaginal incision, could also potentially distort the anatomy causing entry into the peritoneal cavity to be more difficult. For example, if the injection is placed too deeply into the tissue, the injected fluid may displace the peritoneum more cephalad from the vaginal incision site. Also, the routine use of blunt dissection to “push” the vesicocervical tissue off the cervix (“pushing the bladder”) may also distort the anatomy. In the sections that follow, techniques are outlined to prevent or address the difficult anterior colpotomy.

## *Sharp Dissection*

The surgeon should maintain sharp dissection of the vesicovaginal space. Blunt dissection with either fingers or sponge may further distort the planes. Also, these techniques may increase the risk of bladder injury, especially if the patient had a previous cesarean section. Often using the back of the scissors with gentile push and cut method will facilitate the dissection. The assistant should be instructed to grasp and elevate the anterior vaginal wall tissue, as this maneuver will typically help the surgeon identify the correct plane.

## *Stay Close to the Cervix and Uterus During Dissection*

Typically, the surgeon is conscious of the risk of bladder injury during the dissection for anterior colpotomy. However, one should avoid “overcorrection” with resultant dissection into the cervix. Often this is marked by increased bleeding (**FIG. 22.18**).

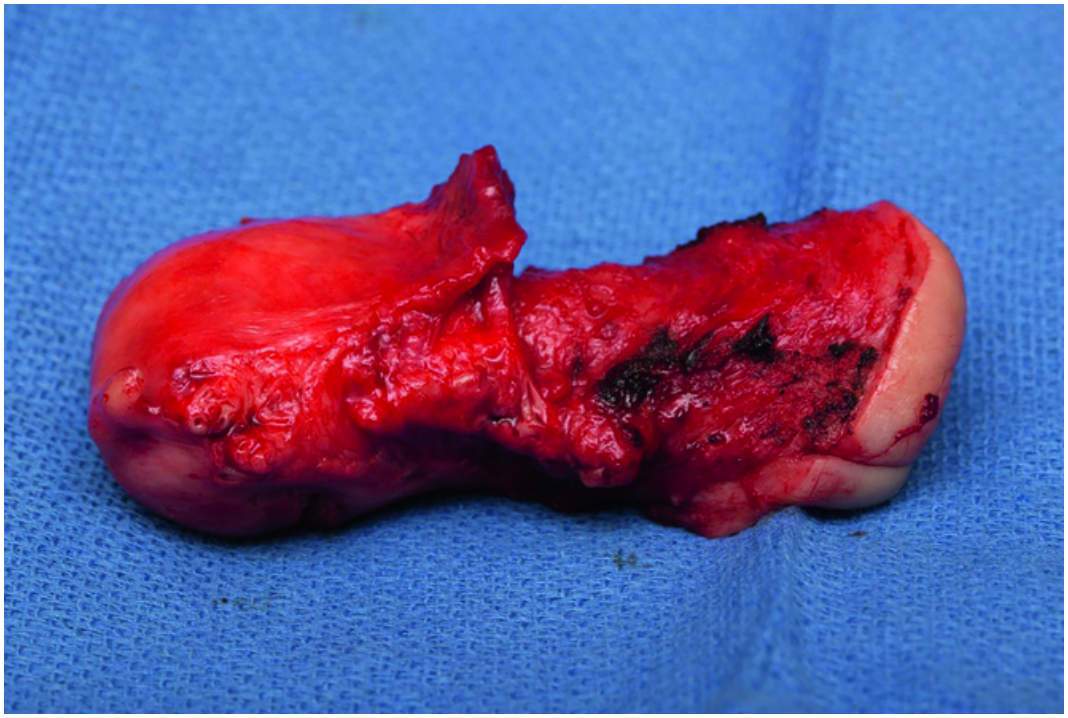


**FIGURE 22.18** Lateral view of a hysterectomy specimen showing the dissection carrying “too deep” and into the uterus. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

In some cases of prior uterine incisions, such as prior cesarean delivery, further dissection cranial to the scar can be performed by maintaining close dissection on the uterus and identifying the scar. In some instances, it may be possible to identify and dissect around or under the scar. This technique keeps the dissection even further from the urinary bladder (**FIG. 22.19**; **VIDEO 22.5**).

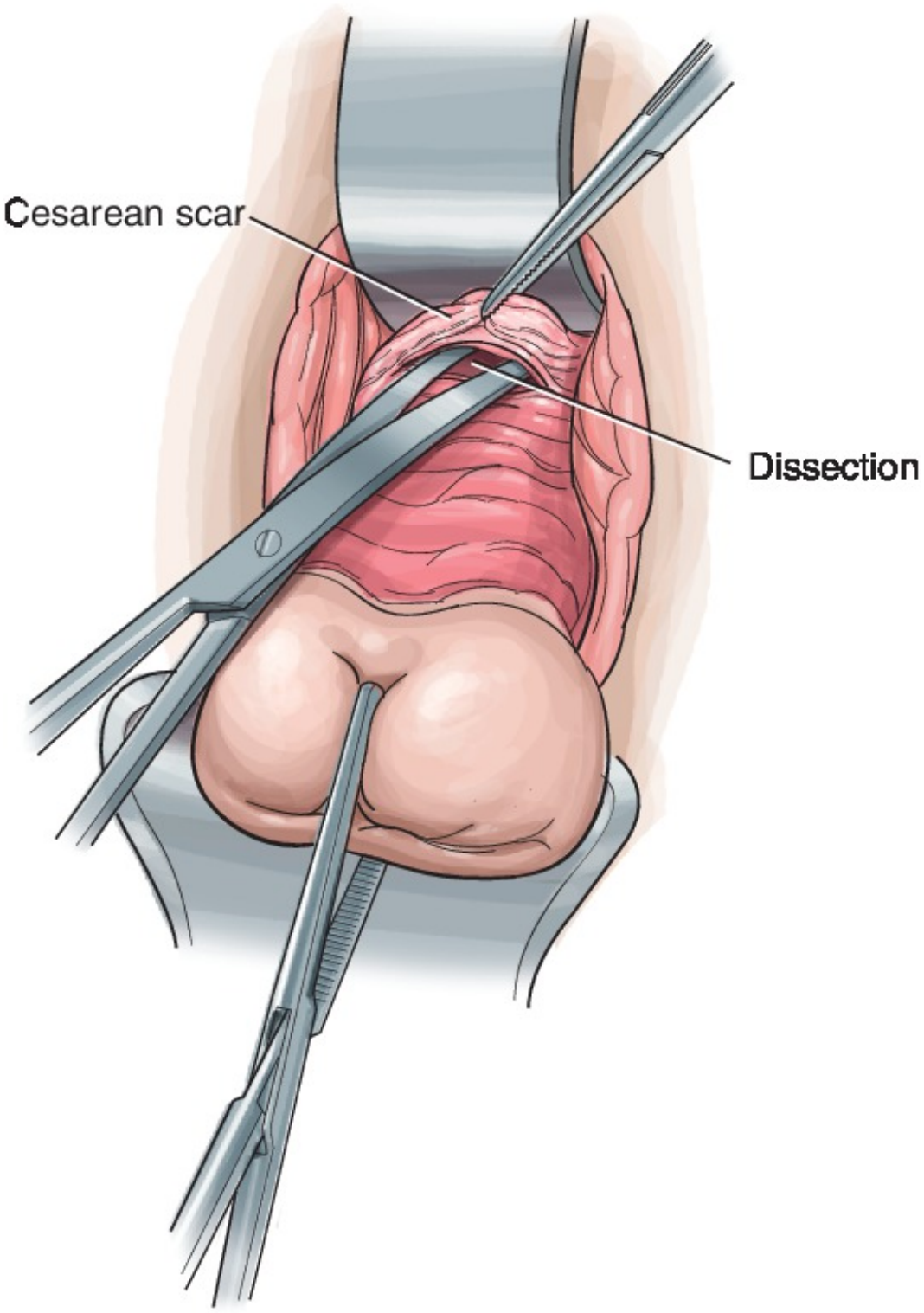



**FIGURE 22.19** Sometimes it is possible to dissect beneath the cesarean section scar to

gain entry into the superior part of the vesicouterine space to identify the anterior peritoneal fold.

### *Retrograde Fill the Bladder*

If the surgeon has emptied the bladder before the case, retrograde filling the bladder may also help to identify the plane between the bladder and the uterus. With the bladder more distended, the surgeon can better delineate the correct plane. Keep in mind that filling the bladder may distend it more cephalad, which is less helpful in delineating the vesicouterine space. Another technique is to insert a uterine sound, bent into a “U” shape, through the urethra and into the bladder. The surgeon can then palpate the tip of the sound, use it to identify the bladder margin, and manipulate the sound position to displace the bladder toward the surgeon. Finally, the illumination from a cystoscope placed into the bladder allows demarcation of the bladder base.

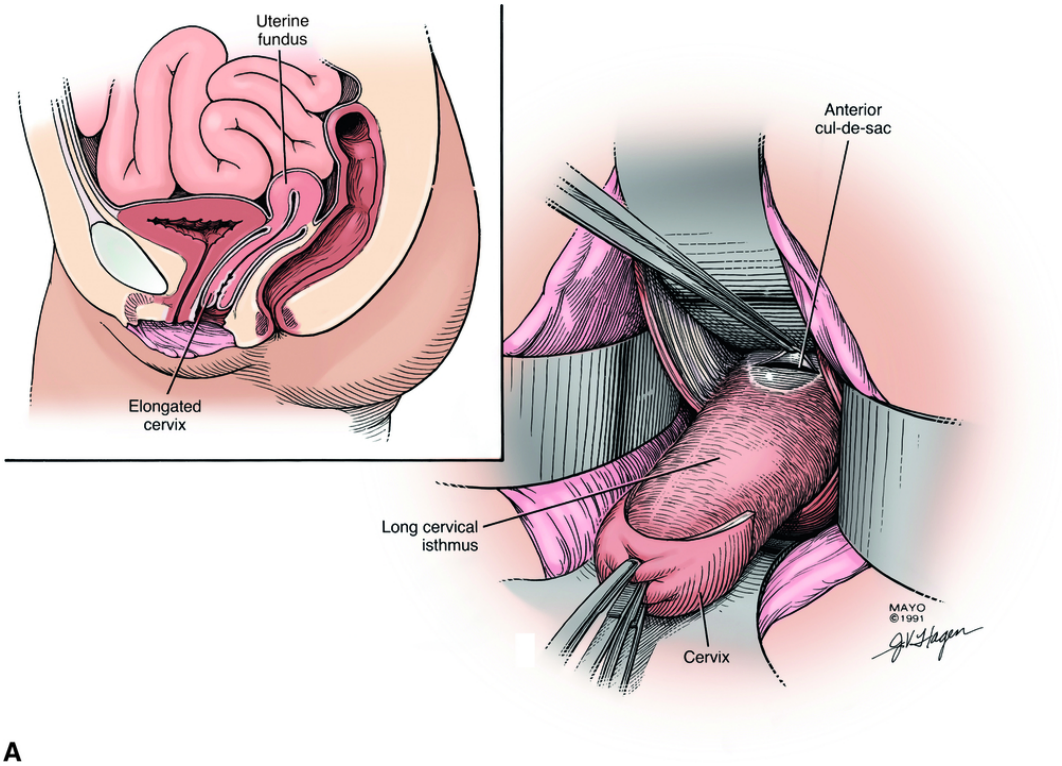
### *Define the Reflection With a Blunt Instrument From Above*

If one can still not enter the peritoneal cavity anteriorly in the case of a small uterus, the surgeon can pass a finger or instrument (preferably a blunt curved instrument) through the posterior colpotomy, around the uterine fundus, and into the anterior space. This instrument can be used to identify the vesicouterine fold (allowing the surgeon to incise the peritoneum over the finger or instrument).

## Cervical Elongation

Sometimes it is difficult to enter the anterior peritoneum due to cervical elongation. In these cases, the peritoneal reflection is often higher (both anteriorly and posteriorly) than anticipated (**FIG. 22.20**).

When cervical elongation is encountered during the initial examination, it may be particularly useful to plan a posterior entry first. A V-shaped incision posterior to the cervix may also allow easier access to the posterior cul-de-sac, which may help facilitate entry.

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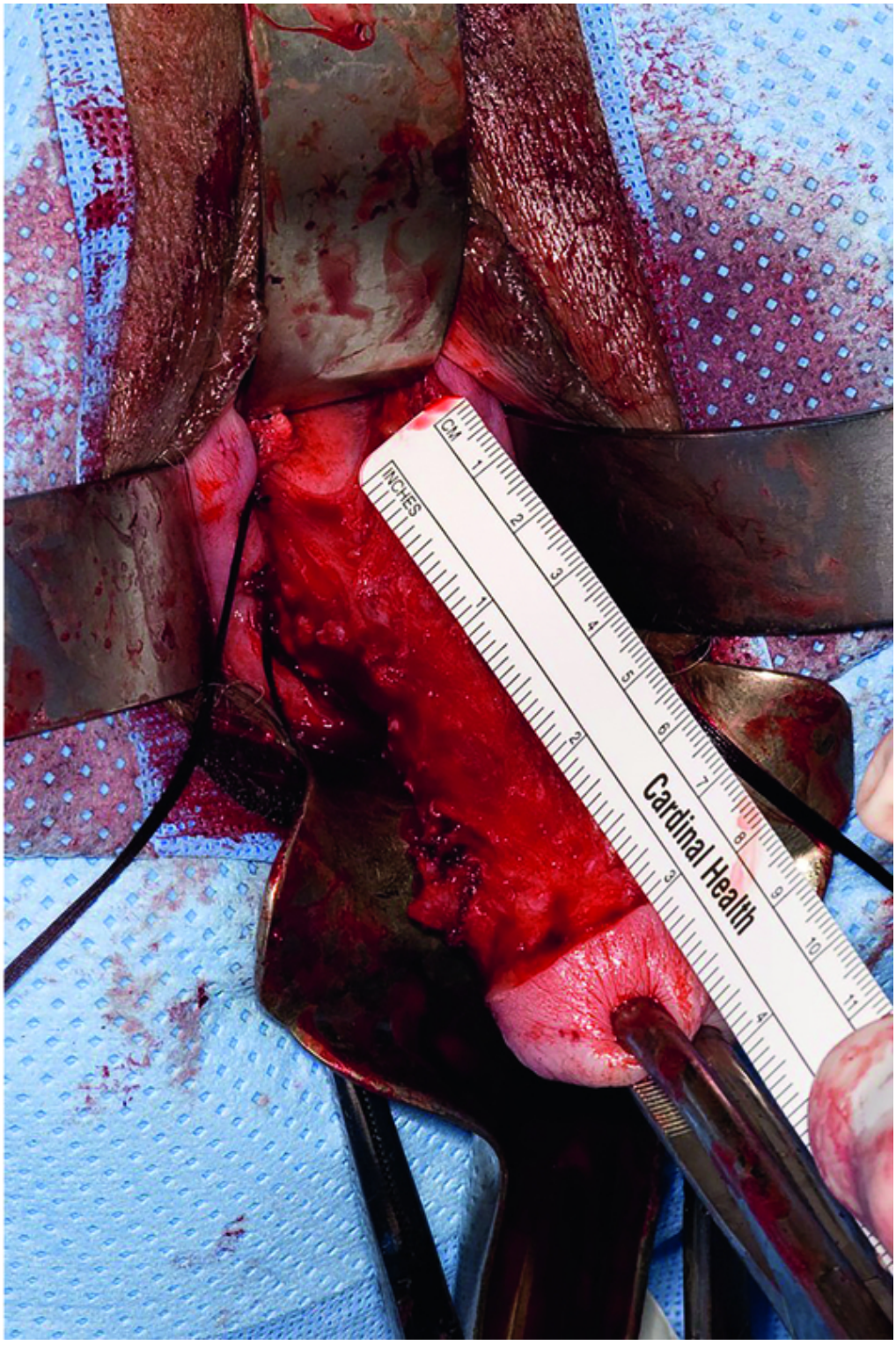


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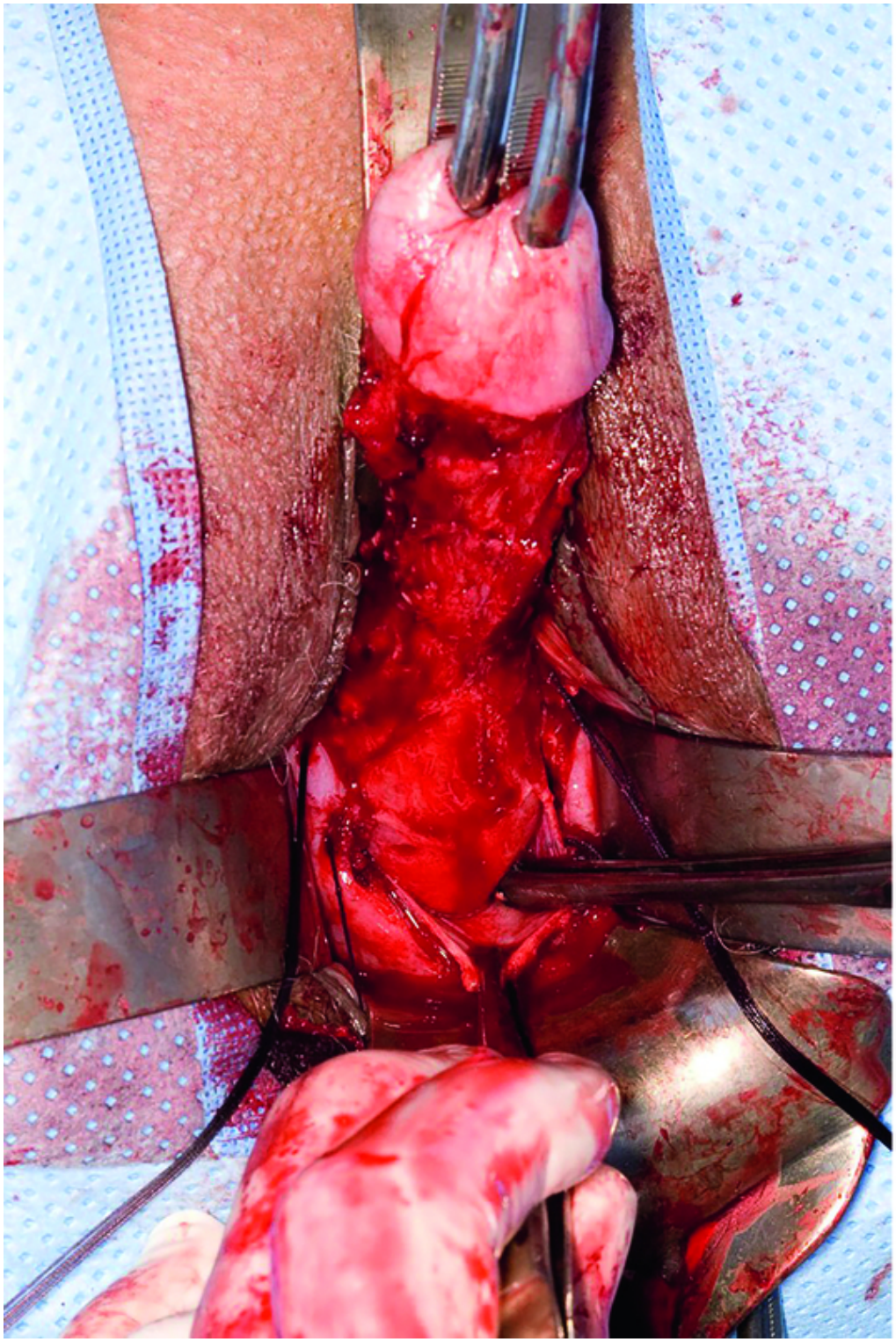


C

**FIGURE 22.20 A.Inset figure A** is a lateral view of the pelvis with an elongated cervix

and high peritoneal location both anteriorly and posteriorly. **Inset figure B** shows a long plane of dissection until reaching the anterior peritoneum. **B.** The anterior peritoneum at 8 cm from the initial incision. **C.** The posterior peritoneum in a similar position to the anterior. Patience and additional clamping may be required until reaching the peritoneal reflection. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

After entering the posterior cul-de-sac, the anterior vagina should be advanced off the cervix as much as possible. The anterior dissection may be difficult in extreme cervical elongation. If the anterior peritoneal reflection cannot be identified, the uterosacral ligaments should be identified, clamped, and suture ligated bilaterally. As the uterus descends, the anterior dissection is reevaluated to look for the anterior peritoneal fold. If anterior cul-de-sac entry is still unobtainable at this point, the cardinal ligaments can be clamped and incised (after assuring that the bladder is retracted anteriorly). In the case of cervical elongation, this technique can be repeated until the peritoneal reflection is visualized (**FIG. 22.21**; **VIDEO 22.6**).

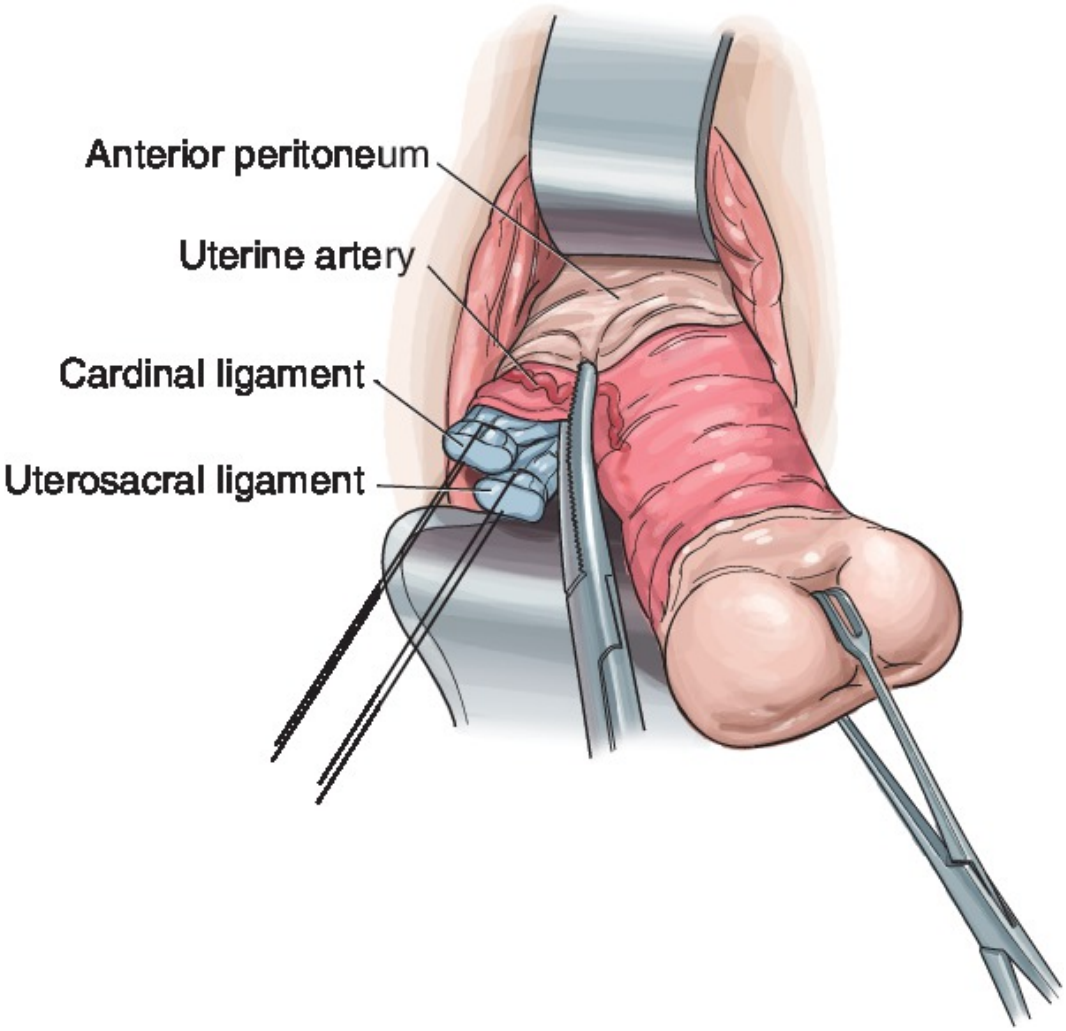



**FIGURE 22.21** If the anterior colpotomy cannot be easily created, the surgeon can proceed with dividing and ligating the uterosacral and cardinal pedicles. The uterine vessels can be clamped prior to entry into the anterior peritoneum. Often, the anterior peritoneal reflection is opened as a result of securing the bilateral uterine artery pedicles.

If the above strategies are not successful, delaying anterior entry is an option. Once uterosacral and cardinal ligaments are transected,

this will increase uterine descensus and may allow for subsequent successful anterior entry.

# Enlarged Uterus

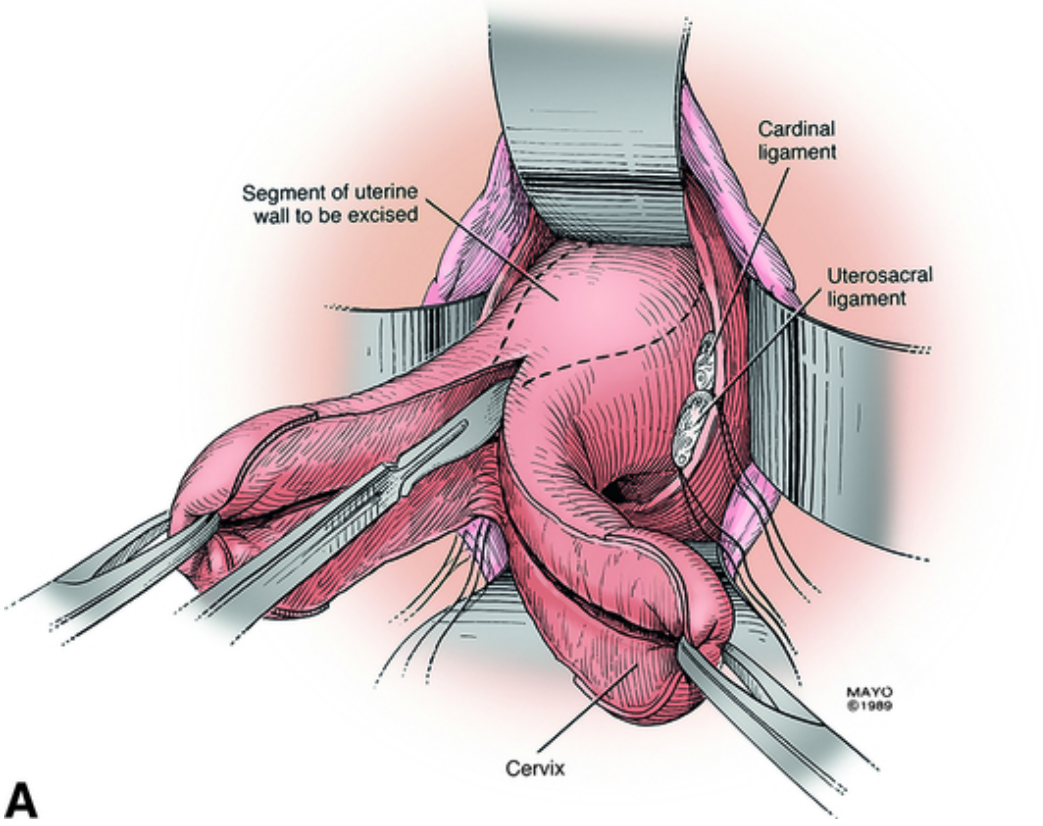
The upper limit of uterine size for vaginal hysterectomy has not been established. However, many surgeons regard 16-week size as a reasonable and practical upper limit for removal using the vaginal approach. An important consideration is where the bulk of the uterus is located. For example, a 20-week size uterus because of a pedunculated fundal myoma is a relatively straight forward vaginal case, whereas a moderate sized myoma in the lower uterine segment may make a vaginal approach challenging.

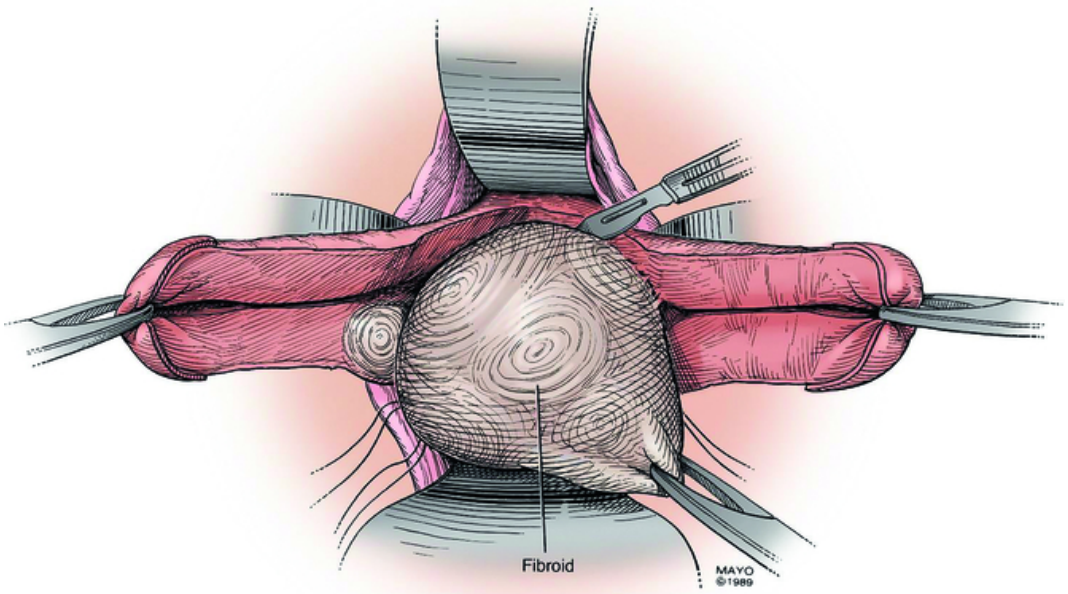
Sharp debulking/morcellation techniques, including bivalving or coring the uterus, may be required to remove the enlarged uterus. Prior to morcellation, it is important that all uterine vessels are secured, and it is preferable to have entered both cul-de-sacs as well. However, this is not always feasible depending on the size and shape of the uterus. All morcellation techniques should be performed under direct visualization to avoid inadvertent injury to the neighboring anatomical structures such as the bowel and bladder. Morcellation should be avoided in cases of known malignant or premalignant conditions.

## *Bivalve*

This cannot be done until after the uterine vessels are secured. This is our preferred technique. The cervix is grasped with a double-tooth tenaculum at 3 o'clock and another at 9 o'clock. A right-angle retractor is placed along the posterior wall into the posterior cul-de-sac to protect posteriorly and a Deaver or right-angle retractor is placed in the 12 o'clock position to protect the bladder. With traction, the cervix is divided in a vertical fashion until the enlarged fundus is encountered (**FIG. 22.22**). At this point, leiomyomata or myometrial segments can be removed using several types of sharp and blunt dissection until the fundus is sufficiently reduced in size to allow completion of extirpation of the organ. Instruments such as Cobb

tissue elevators may be used to help enucleate individual myomas. We feel it is important to keep the lateral and superior margins of the uterus intact (debulk the middle) to maintain orientation while operating and to allow easier pathologic assessment (**FIG. 22.23**; **VIDEO 22.7**).






B

**FIGURE 22.22** Bivalve technique of morcellation. This technique can only be used after the uterine arteries are secured; typically, both the anterior and posterior peritoneum have been entered, and the bladder is retracted anteriorly with a Deaver retractor. **A.** A double-tooth tenaculum is placed on either side of the cervix, and the cervix is divided in the midline, following the endocervical canal. **B.** As the body of the uterus is divided similarly, always under direct visualization, the tenaculum can be advanced. The medial aspects of the body of the fundus can be excised, reducing uterine bulk and allowing the utero-ovarian pedicles to be secured.

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**FIGURE 22.23** Surgical specimen after the bivalve technique. Note that the lateral and superior boundaries of the uterus are preserved. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

## *Intramyometrial Coring*

This cannot be done until after the uterine vessels are secured. The myometrium can be circumferentially incised with a scalpel placed parallel to the long axis of the uterus and beneath the serosal

covering of the uterus (**FIG. 22.24**). In effect, coring converts the normal spherical shape of the uterus into an elongated cylindrical or rod shape, enhancing the surgeon's ability to facilitate uterine removal. It is important to maintain orientation of the uterus at all times to prevent extending the dissection laterally or beyond the serosa.

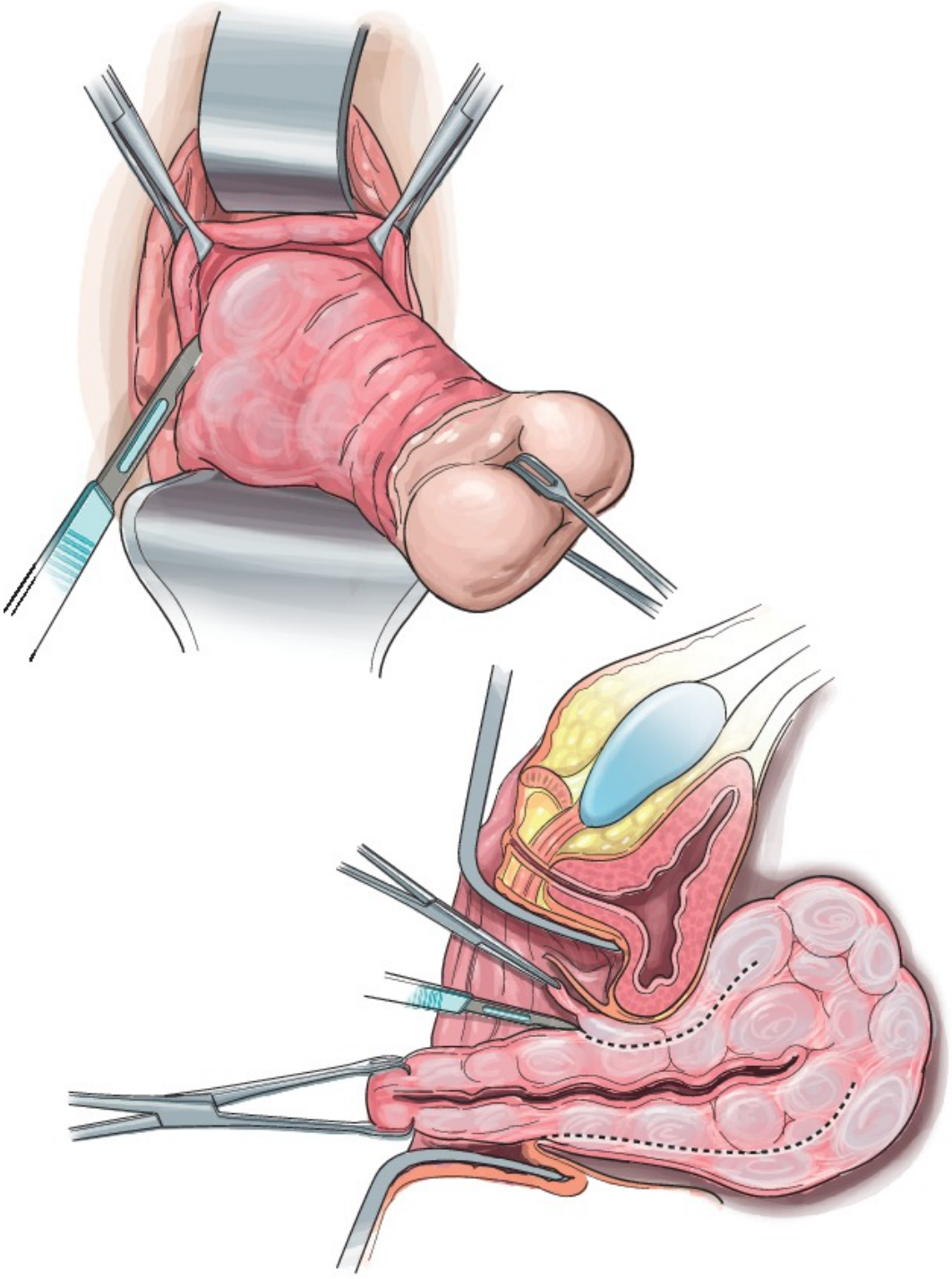

**FIGURE 22.24** Coring technique of morcellation. This technique can only be performed after the uterine arteries are

secured and both the anterior and posterior peritoneum have been entered. With traction on the cervix, the surgeon creates a circumferential incision into the myometrium to excise, as a “core,” as much myometrial tissue as possible. It is critical that the myometrium is incised under direct visualization; typically, traction on the cervix will allow the “core” to descend, but this can also distort the anatomy. It is important that the surgeon does not perforate the uterine serosa.

## *Minimal Descensus*

Nulliparous patients or women who have not experienced a vaginal birth may have limited uterine descent on preoperative examination in the office setting. However, this should not discourage the surgeon from attempting a vaginal approach. An evaluation after induction of anesthesia may reveal increased mobility of the uterus. Additionally, there are surgical techniques that can be utilized to maximize the descent of the uterus.

One technique for improving uterine decent is described as follows: Initial incision can be made in a “key hole” or V-shaped fashion instead of the traditional circumferential vaginal incision. This is performed by extending the posterior incision toward the uterosacral ligaments allowing for easier access to the posterior cul-de-sac. The uterus is then elevated, and the posterior cul-de-sac is entered first. This allows access to the uterosacral ligaments and cardinal ligaments that are transected and suture ligated. This typically results in more uterine descent and facilitates access to the anterior peritoneal cavity.

# ADNEXECTOMY AT THE TIME OF VAGINAL HYSTERECTOMY

Success rates for bilateral salpingo-oophorectomy at the time of vaginal hysterectomy ranges from 65% to 97.5%. Factors such as nulliparity, narrowed pubic arch, obesity, and uterine enlargement have all been shown to have a negative impact on successful completion of this procedure. We use a tagged pack to elevate the bowel out of the pelvis to improve visualization and access to the adnexa (**VIDEO 22.8**).

Salpingectomy (with ovarian conservation) should be considered at vaginal hysterectomy. In 2015, The American College of Obstetricians and Gynecologists published a Committee Opinion that stated "the surgeon and patient should discuss the potential benefits of the removal of the fallopian tubes during a hysterectomy in women at population risk of ovarian cancer who are not having an oophorectomy." Although this procedure can be technically more challenging (when compared to removing the tubes at laparotomy), opportunistic or elective salpingectomy can be successfully and safely performed via the vaginal route in most cases. One study reported that salpingectomy at the time of vaginal hysterectomy was successful in 88% of cases in which it was planned. Overall complication rates were 15%, with 3.8% possibly attributable to salpingectomy; the presence of pelvic adhesions was associated with failure to complete the procedure. Another study reported comparable success rates (81%), and it was noted that the addition of salpingectomy at the time of vaginal hysterectomy increased operating time by 11 minutes and blood loss by 6 mL. In this study, prior adnexal surgery and uterine fibroids were the only significant factors associated with unsuccessful adnexectomy.

## Technique for Salpingo-oophorectomy at Vaginal Hysterectomy

Upon removal of the uterus, routine inspection of the adnexa should be performed on all patients undergoing a vaginal hysterectomy. This can be facilitated with lateral and inferior traction on the tagged utero-ovarian pedicle clamps. A right-angle or Deaver retractor is placed laterally, into the peritoneal cavity. If the adnexa cannot be visualized using this technique, then a Babcock clamp or Russian forceps can be used to gently manipulate the tissue of the meso-ovarian to guide the ovary into the operative field for inspection. In some cases, loops of bowel may limit visualization and repositioning of the pack and steep Trendelenburg position may resolve this problem.

The tube and ovary are then grasped with a Babcock or Allis clamp, and gentle traction of the adnexa is applied toward the midline. Next, a Heaney clamp can be placed lateral to the utero-ovarian pedicle and advanced superiorly above the tube and ovary to clamp across the infundibulopelvic ligament and secure the gonadal vessels (**FIG. 22.25**). An absorbable suture, as a free tie or tie on a passer (depending on the proximity of the adnexa to the cuff opening), is placed around the Heaney clamp and tied down. We prefer this technique as it allows the surgeon to secure the vascular pedicle prior to excising the specimen. This pedicle can be doubly clamped (and doubly ligated), but sometimes there is only room for one clamp. In this case, as the first ligature is tied down the clamp may be “flashed” as the suture is tied, securing the vessels. The specimen is then excised. The pedicle is then suture ligated using an absorbable suture. It is critical that hemostasis be assured before cutting this suture because once tension is released, the tissue will retract into the peritoneal cavity and will, therefore, be inaccessible.

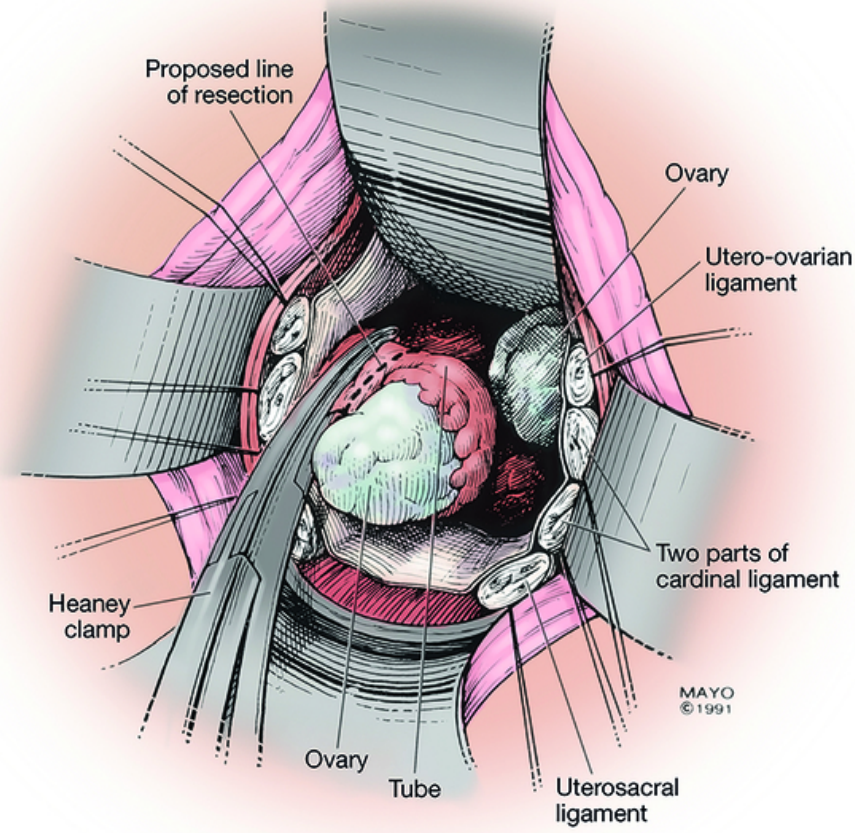


**FIGURE 22.25** Salpingectomy or salpingo-oophorectomy may be accomplished after hysterectomy. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.)

Some other techniques of removing the adnexa at the time of vaginal hysterectomy have been described and may also be utilized; particularly in cases where there is limited access to the adnexa and vessels. Laparoscopic or handheld electrosurgical vessel-sealing devices may be used via the vaginal approach to remove the

adnexa. An Endoloop placed around a Heaney clamp may assist in securing the infundibulopelvic ligament first; then suture ligated in the traditional fashion as described above.

In some situations, due to limited access or concerns for nearby structures, the fallopian tube and ovary must be ligated as separate pedicles. This will often allow better visualization of the entire pelvic sidewall (VIDEO 22.9).

# COMPLICATIONS OF VAGINAL HYSTERECTOMY

The overall complication rate for vaginal hysterectomy is low. Complications are categorized as intraoperative (those occurring during the procedure) and postoperative (those that occur in the postoperative period).

Hemorrhage and visceral injury are the most common intraoperative complications. Reported rates of excessive hemorrhage range from 1.4% to 2.6%, and this is usually a result of a vascular pedicle that has retracted or loosened from the tie. If this bleeding is not recognized intraoperatively, it may present as increased postoperative vaginal bleeding or rapid deterioration in vitals with increasing abdominal or flank pain. Both scenarios require immediate assessment and intervention to ensure stabilization. If bleeding is suspected but the patient is stable, the surgeon may consider imaging to identify a bleeding source, possibly followed by selective angiographic embolization. An unstable patient with suspicion of bleeding needs to return to the OR for assessment. The vaginal approach could be attempted first (to assess the bleeding). However, if excessive hemorrhage is noted superior to the vascular pedicles, laparotomy or laparoscopic evaluation may be warranted.

Injury to the urinary tract is a risk of hysterectomy by any route; however, rates of urinary tract injury are lowest for the vaginal approach when compared to laparoscopic or open routes. When the vaginal hysterectomy is performed without any additional surgeries, reported rates of bladder and ureteral injury are 1.8% and up to 0.9%, respectively. When bladder injuries occur during a vaginal

hysterectomy, it usually occurs with the dissection for anterior colpotomy. The injury is usually superior to the trigone of the bladder and away from ureteral orifices. If it is recognized while performing the hysterectomy, the repair of the cystotomy should be delayed until removal of the uterus. This is recommended in case there is additional injury to the bladder and allows for easier access to the cystotomy site with the uterus removed. We prefer to tag the injury with a loosely tied suture for later identification after uterine removal. Occasionally, when the anterior dissection is very difficult and incidental cystotomy occurs, the surgeon can place a finger in the cystotomy to facilitate identification of the correct surgical plane to complete the dissection.

Injury to the bowel occurs in 0.4% of women undergoing vaginal hysterectomy, and it can occur because of a difficult posterior entry into the posterior cul-de-sac. If recognized intraoperatively, the area of injury should be held gently with an atraumatic grasper to avoid the bowel from retracting back into the peritoneal cavity. The intraperitoneal cavity is then copiously irrigated with normal saline, and the bowel is repaired by a surgeon experienced in bowel repairs.

Not all injuries to the viscera are recognized intraoperatively. Injury to the bowel or bladder may result in fistula formation several weeks after the surgery. This complication may require a return to the operating room for subsequent repair. Fistula is reported in 0.1%-0.2% of patients after a vaginal hysterectomy.

The most common postoperative complication is urinary tract infection. This can typically be treated with oral antibiotics. Pelvic infections after vaginal hysterectomy include vaginal cuff cellulitis and pelvic abscess. These infections occur in ~4% of women. Rates of infection are significantly reduced with appropriate use of prophylactic antibiotics and preoperative vaginal preparation. Approximately one-third of women who did not receive prophylactic antibiotics will develop pelvic cellulitis. Cellulitis is more prevalent in women with bacterial vaginosis, among those who have a prolonged surgery and among those who had excessive intraoperative blood loss. Patients with cuff cellulitis usually respond quickly to antibiotics. A pelvic abscess at the vaginal cuff or the adnexa should be

suspected in patients with pelvic or cuff cellulitis who have not improved in 24-48 hours after starting parenteral antibiotics.

Pelvic hematoma may also develop in the postoperative period and may be asymptomatic; however, patient may present with an unexplained drop in their hemoglobin and fever as well. Pelvic hematoma can readily be seen on postoperative pelvic imaging. Generally, the blood will be reabsorbed without any interventions; however, drainage may be necessary in larger hematomas or ones that become infected.

# POSTOPERATIVE CARE

In most instances, patients may be discharged on the day of surgery. Patients who are admitted after a vaginal hysterectomy are encouraged to ambulate and their diet should be advanced as tolerated. The risk of ileus is low (0.2%) after vaginal hysterectomy.

Typically, the bladder catheter may be removed immediately upon completion of the surgery or in the recovery room. However, the patient should be evaluated for possible voiding dysfunction in the immediate recovery period. We prefer to place a catheter at the completion of the case and perform a retrograde voiding trial prior to discharge. In a study evaluating the impact of immediate catheter removal in patients undergoing vaginal or laparoscopic hysterectomy, 21% of women developed postoperative voiding dysfunction of whom 13.7% had complete urinary retention. Women who had undergone a vaginal hysterectomy were more likely to develop voiding dysfunction. None of the patients experienced voiding dysfunction beyond 48 hours.

There is no standard recommendation for when patients should be evaluated in the postoperative period. If there are no known complications in the immediate postoperative period, patients are often seen 6 weeks of the surgery to assess healing of the vaginal cuff. Patients are advised to avoid immersion in water and avoid placing anything in the vagina, including sexual intercourse in the immediate postoperative period. Although intercourse and vaginal instrumentation are proposed risk factors for vaginal cuff dehiscence, their association with dehiscence has not been proven.

# HYSTERECTOMY SIMULATION

Simulation in surgical education has grown exponentially over the past 15 years with repetition being of premier importance in surgical skill development. With regard to vaginal hysterectomy, simulation contributes to trainee understanding of 3-dimentional pelvic anatomy and can improve surgical confidence. Procedural steps can be practiced repeatedly until comfort is achieved all while remaining in a low-risk, educational environment. A variety of simulators have been described ranging from a low-fidelity model described by Barrier to the highest fidelity model available, the Miya Model (Miyazaki Enterprises; Winston Salem, NC), which has been validated for assessment of vaginal hysterectomy skills assessment.

## KEY POINTS

- Surgeons should consider the vaginal route as the primary approach for hysterectomy. It is the least invasive approach and is associated with fewer injuries, less pain, and lowest costs.
- There are few absolute contraindications to a vaginal approach to hysterectomy. A history of pelvic surgery, prior cesarean section, an enlarged uterus, and planned adnexal removal should not preclude the vaginal approach.
- When guidelines are used to determine the most appropriate route of hysterectomy, the percentage of vaginal hysterectomies for benign conditions will be >90%.
- Bilateral salpingo-oophorectomy at the time of vaginal hysterectomy should be technically feasible in more than 80% of patients.


# ACKNOWLEDGMENTS

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# CHAPTER 23

# ABDOMINAL HYSTERECTOMY

Laurie S. Swaim and Audra E. Timmins

**History of Total Abdominal Hysterectomy**
**Incidence and Trends**
**Indications for Hysterectomy**
Opportunistic Salpingectomy
**Surgical Approach**
**Preoperative Evaluation and Management**
Uterine Size
Medical Management of Preoperative Anemia
**Technique of Abdominal Hysterectomy**
**Special Situations**
Supracervical (Subtotal) vs Complete (Total) Hysterectomy
Appendectomy
Culdoplasty
Abdominoplasty
**The Challenging Hysterectomy**
Obliteration of the Cul-de-Sac
Cervical and Lower Uterine Segment Fibroid
**Postoperative Care**
**Reduction of Perioperative Risk**

Ureteral Stents
Universal Cystoscopy
Intraoperative Techniques to Reduce Blood Loss
Prevention of Adhesion
**Risks Associated With Abdominal Hysterectomy**
Transfusion
Postoperative Infection
Cuff Dehiscence
Urinary Tract Injury
Gastrointestinal Injury
Complications Related to Adhesion
Postoperative Neuropathy
Regret Childbearing/Reproductive Options
Sexual Function
Incontinence
Prolapse
Menopause
Effect on Metabolic Disorders and Cardiovascular Disease
Mortality
Readmission
Learners and Hysterectomy

# HISTORY OF TOTAL ABDOMINAL HYSTERECTOMY

In his “Essays on the Position of Hysterectomy in London,” John Bland-Sutton described some of the changes he observed in technique and patient evaluation that contributed to a remarkable reduction in mortality from 18.3% to 3.0% between 1896 and 1906. During this era, the hysterectomy mortality rate at Johns Hopkins was 5.9%. Thus, surgeons in the late 1800s were undoubtedly frustrated with their inability to prevent common causes of hysterectomy-related deaths.

Dr. Sutton’s plea for surgeons and their assistants to don sterilized rubber gloves during hysterectomy is an enlightening reminder of the status of scientific evidence at the time. Without the benefit of computerized databases and randomized trials, physicians relied on case review and trial and error to reduce the risk of abdominal hysterectomy. Death from sepsis, pulmonary emboli, and hemorrhage notwithstanding, Dr. Sutton noted in 1909 that abdominal hysterectomy had “become a fairly safe proceeding” but cautioned that surgical risk was still a concern even with modern “surgeries.” A hysterectomy-associated mortality rate of 3% is appalling by modern standards, but considering the perils of hysterectomy in the mid-19th century, Dr. Sutton’s impression was probably justified.

Risk reduction strategies were not referred to as such, but surgeons in 1906 recognized that mortality and surgical duration were directly linked. According to Dr. Sutton, hysterectomies completed in <30 minutes by a “dexterous and careful surgeon” were associated with improved chances of survival, at least in part because pulmonary emboli are “more frequent in the practice of those who habitually operate slowly.” “Slowly,” as defined by Dr. Sutton, equals 2 hours. What a difference a century makes. The benefits of antibiotics, anesthesia, thromboembolism prophylaxis, blood banking, and refinements in surgical technique are abundantly clear. The mortality rate associated with hysterectomy for benign disease is now <0.2%.

Morbidity rapidly declined as advancements in technique reduced blood loss and surgical duration. Hemorrhage was a constant fear when surgeons relied on single ligatures to control bleeding during uterine amputation. Suggested by A. M. Heath in the

mid-19th century, it was not until 1892 that Baer secured the uterine arteries separately leading to safer subtotal hysterectomy. The basic technique of abdominal hysterectomy remained relatively unchanged until Richardson introduced total hysterectomy in 1929. In the eleventh edition of Te Linde, Dr. Howard Jones reminded us that the technique of abdominal hysterectomy taught today is based on modifications of the Richardson method, which Te Linde thought was classic.

# INCIDENCE AND TRENDS

The number of hysterectomies in the United States reached a peak of 681 234 in 2002 but has since declined, with substantial decreases in the percentage of abdominal hysterectomy and increases in laparoscopic hysterectomy for benign disease. In North America, the percentage of hysterectomies performed abdominally decreased from 66% in 2003 to 36.9% in 2017, while the number of laparoscopic hysterectomies increased. After the release of the 2014 U.S. Food and Drug Administration (FDA) statement discouraging power morcellation for fibroids, a shift away from laparoscopic hysterectomy was associated with an increased rate of abdominal hysterectomy. This trend, however, reversed 1 year after the release of the FDA communication.

Patient demographics are associated with hysterectomy rate and route. Even after controlling for demographic and clinical factors, Black women are nearly two to four times more likely than White women to undergo hysterectomy for fibroids. Conversely, hysterectomy rates of Asian women are about half those of White women. Comparative hysterectomy rates among Hispanic women are more difficult to ascertain because of conflicting data. Data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) regarding hysterectomy performed between 2014 and 2017 for leiomyoma indicate that Black and Hispanic women were significantly more likely to undergo abdominal over laparoscopic or vaginal hysterectomy than White women, even after controlling for confounders. Furthermore, the incidence of postoperative urologic and gastrointestinal complications, SSI, and

readmission are all higher for Black compared to White, Hispanic, and Asian/Pacific islander patients after abdominal hysterectomy. These differences raise concerns about disparities in access to and quality of care.

# INDICATIONS FOR HYSTERECTOMY

While the decision to proceed with hysterectomy may be straightforward in some cases, it is incumbent on the surgeon to explore nonsurgical options. This is especially true when evidence suggests that conservative means of therapy offer reasonable long-term symptomatic relief or treatment.

The most common indications for hysterectomy in the United States are uterine fibroids and abnormal uterine bleeding (AUB), followed by pelvic organ prolapse. Hysterectomy may also be indicated in the treatment of symptomatic adenomyosis, endometriosis, cervical dysplasia, endometrial hyperplasia, surgical management of a benign adnexal mass, complete hydatidiform mole in women over 40, and (in some instances) chronic pelvic pain. Patients with known genetic predisposition for developing uterine cancer are also candidates for hysterectomy.

## Opportunistic Salpingectomy

Epidemiologic evidence suggests that bilateral salpingectomy is associated with a reduced lifetime risk of ovarian cancer. Canadian researchers observed significantly fewer ovarian cancers than expected after opportunistic salpingectomy compared to patients undergoing hysterectomy alone or tubal ligation. While the study period was short (3.2 years after opportunistic salpingectomy), the authors conclude that salpingectomy is associated with a potential reduction in lifetime risk of serous cancers by up to 80%. Therefore, opportunistic salpingectomy should be recommended at the time of abdominal hysterectomy (when surgically feasible). A 2019 Cochrane analysis comparing surgical complication rates among women after hysterectomy with and without salpingectomy reported insufficient data to determine differences. The same review found no

clinically important effect of bilateral salpingectomy on antimüllerian hormone decline, but cautioned that such effects could be clinically relevant. The surgeon should discuss this uncertainty with the patient as part of the informed consent process. Estimated blood loss, surgical procedure length, and hospital admission are not adversely affected by salpingectomy at the time of abdominal hysterectomy.

# SURGICAL APPROACH

Comparison of patient outcomes after vaginal, laparoscopic, and abdominal hysterectomy consistently shows that the abdominal approach is associated with an increased length of hospital stay, less rapid return to normal activities, and marked increase in surgical site infection rates. Therefore, the abdominal route for hysterectomy is best reserved for situations in which minimally invasive approaches are not reasonable.

Anatomic factors influencing the route of hysterectomy include the size, shape, and lateral extent of the uterus; uterine support; suspected pelvic adhesion; the angle of the pubic arch; and the extent of pathology. Medical disorders potentially exacerbated by increased intra-abdominal pressure due to insufflation or steep Trendelenburg position may also affect the decision. The abdominal route is sometimes more appropriate when orthopedic conditions restrict or prevent the patient from assuming the lithotomy position.

Uterine size >12 weeks has historically been an indication for abdominal hysterectomy. However, studies of vaginal and laparoscopic hysterectomy performed by experienced surgeons support a minimally invasive approach in well-selected patients with large uteri. Using a clinical decision tree algorithm, Schmitt et al. recommend vaginal or hysterectomy (over abdominal hysterectomy) for patients with uterine size <18 weeks due to reduced surgery time, surgical site infection rates, and cost. Uccella et al. retrospectively compared outcomes of patients with uteri weighing >1 kg undergoing abdominal and laparoscopic hysterectomy by experienced surgeons. Women undergoing laparoscopic hysterectomy had a reduced incidence of overall complications as compared to those managed

with abdominal hysterectomy (OR, 0.42; 95% CI 0.19-0.9). These findings suggest that large uterine size is not an absolute contraindication to a vaginal or laparoscopic approach in the setting of an experienced surgical team.

What then is the role of abdominal hysterectomy for benign disease? The 2011 American Association of Gynecologic Laparoscopists position statement endorses a minimally invasive (vaginal or laparoscopic) approach to hysterectomy except when uterine or adnexal disease or adhesions contribute to anatomic distortion such that the experienced gynecologic surgeon considers the abdominal approach the safest option. Also, appropriately counseled patients may choose the abdominal route over laparoscopic or vaginal if concerned about the potential effects of tissue morcellation. Other indications for the abdominal approach include cardiopulmonary disease (if the risks of anesthesia or increased intra-abdominal pressure are contraindications to laparoscopy and pneumoperitoneum) and when the surgeon anticipates a need for morcellation of the specimen in the setting of known or suspected malignancy. In some cases, an abdominal approach will be selected due to the lack of facilities, instrumentation, or expertise to perform vaginal or laparoscopic hysterectomy. Finally, if operative time is expected to be shorter with an abdominal approach, providers and patients may choose that option in cases of large uteri. Historic concerns such as obesity and anterior abdominal wall hernia should not be considered absolute contraindications to laparoscopic procedures.

Additionally, it is imperative that surgeons recognize the effect of implicit bias when selecting the surgical route. Despite trends toward minimally invasive techniques, Black patients are twice as likely as White patients to have an abdominal hysterectomy, even when accounting for clinical differences such as fibroid size and obesity. Determining the effect of bias on historic data is not possible, but the choice of hysterectomy rates and routes are undoubtedly influenced by multiple physician and patient factors. While health care access is an obvious contributor to these disparities, more subtle causes such as general distrust of physicians, expectation of large fibroid size,

and normalization of heavy menstrual bleeding and anemia among Black patients may be just as impactful.

# PREOPERATIVE EVALUATION AND MANAGEMENT

Before hysterectomy, the preoperative physical examination serves to delineate the extent of pelvic pathology and potentially detect disease of other organ systems, which may affect surgical route and timing. In addition, the abdominopelvic examination should identify impediments to uterine removal and gynecologic pathology unrelated to the indication for hysterectomy. Surgeons characterize patient body habitus, uterine size, mobility, and girth to choose the most appropriate abdominal incision. The decision-making process should be reviewed with the patient prior to the date of surgery so she understands the plan. Findings of an immobile or fixed uterus may indicate adhesion secondary to prior surgery or endometriosis or may be due to a bulky uterus with a cervical or posterior fibroid wedged in the sacral hollow. With such information, the surgeon is able to gauge the degree of expertise needed for surgical assistance. Pelvic organ prolapse or incontinence identified during the pre-op examination deserves proper preoperative evaluation (and surgical management at the time of hysterectomy if appropriate).

Pelvic imaging may be a useful adjunct to surgical planning when the clinical examination is unclear. In some cases, surgeons may obtain preoperative ultrasound, computed tomography, or magnetic resonance imaging for more precise information about uterine size, shape, fibroid location, or adnexal pathology. Ultrasound is commonly performed prior to hysterectomy, although this modality is not superior to bimanual examination for the prediction of uterine weight. In patients with müllerian anomalies, large pelvic masses, advanced endometriosis, or history of radiation, preoperative computed tomography may identify distortion in the course of the ureter. Imaging should be based on individual patient characteristics and clinical judgment.

# Uterine Size

Uterine size is an important consideration in planning hysterectomy. Removal of very large uteri has been associated with blood loss and major surgical complications. In a retrospective review of NSQIP data regarding hysterectomy for benign disease performed between 2014 and 2015, patients with uteri weighing 500, 750, and 1000 g were >30%, 50%, and 80%, respectively, more likely to experience postoperative complications within 30 days of discharge compared to patients with uteri weighing <100 g. Furthermore, abdominal hysterectomy was associated with increased odds of postoperative complications as compared to laparoscopic hysterectomy for each uterine weight (<250 g [aOR, 2.05; 95% CI 1.80-2.33], 250-500 g [aOR, 1.76; 95% CI 1.41-2.19], and >500 g [aOR, 1.35; 95% CI 1.07-1.71]).

# Medical Management of Preoperative Anemia

When hysterectomy is planned in the setting of anemia, a period of medically induced amenorrhea, combined with appropriate iron and nutrient supplementation, can result in a significant increase in hemoglobin. Specifically, preoperative treatment with extended cycle oral contraceptives, a levonorgestrel intrauterine device, etonogestrel subdermal implant, or medroxyprogesterone acetate may diminish uterine bleeding sufficiently to achieve normal hemoglobin levels before surgery. These medications are good options for surgical pretreatment because of ease of use, low cost, and reasonable side effect profile. However, these medications do not change fibroid size, nor have they been shown to reduce surgical duration, intraoperative blood loss, or transfusion during hysterectomy.

Gonadotropin-releasing hormone (GnRH) analogues can be used preoperatively to reduce or eliminate menstrual bleeding and to decrease uterine size among patients with fibroids (although these benefits are lost shortly after cessation of therapy). GnRH analogues

have been used preoperatively since the 1991 randomized controlled trial by Stovall et al., which showed that leuprolide acetate injection administered 12 weeks prior to surgery in patients with fibroids was associated with an average reduction in intraoperative blood loss of 200 mL during abdominal hysterectomy. In a 2017 Cochrane review, Lethaby et al. reported that 3-4 months of pretreatment with GnRH was associated with reduced uterine volume, decreased transfusion, and a reduction in postoperative complications. Other studies have suggested that pretreatment with GnRH may reduce the need for a vertical abdominal incision (because this therapy may allow a surgeon to accomplish an abdominal hysterectomy via a transverse rather than a vertical incision). GnRH pretreatment is also associated with shorter surgery and reduced length of hospital stay. Surgeons should balance these benefits against the cost and associated side effects (such as hot flashes). Also, in some cases, it is not prudent to delay surgery for 3-4 months for GnRH treatment.

Selective progesterone receptor modulators (such as ulipristal) appear to reduce uterine volume and increase preoperative hemoglobin levels as compared to placebo. However, the FDA and the European Medicines Agency have restricted Ulipristal from the treatment of fibroids secondary to evidence of severe liver damage with extended use. Furthermore, the reduction in uterine size after GnRH pretreatment was twice that seen with ulipristal acetate (−47% vs −20% to 22%).

Administration of intravenous iron therapy with or without erythropoiesis-stimulating agents reduces transfusion rates in orthopedic, obstetric, and colorectal surgical patients by 20%-43%. Although AUB is one of the most common reasons for hysterectomy, the use of intravenous iron for the management of perioperative anemia in gynecology patients has not been studied.

# TECHNIQUE OF ABDOMINAL HYSTERECTOMY

Patients are typically supine with their arms to the side during abdominal hysterectomy. However, the low lithotomy position is ideal because repositioning is not required for cystoscopy and this position also allows for assessment of vaginal bleeding, if present. Also, if the patient is in low lithotomy position, three surgeons can stand comfortably at the operating table, which is quite useful when one or more learners is operating. Regardless of the position chosen, it is incumbent on the surgeon to ensure adequate padding to prevent postoperative neuropathy and to insure skin integrity. Particular attention to the degree of limb rotation and joint flexion prevents most position-related neuropathies. Safe positioning for surgery is reviewed in detail in Chapter 5.

Examination under anesthesia may uncover potential challenges to uterine removal that were not evident at the time of the office examination. This examination may also highlight the need for specific instruments that may not be part of the standard abdominal hysterectomy instrument set.

After proper positioning of the patient and examination under anesthesia, the patient's abdomen and vagina are prepped with an antiseptic solution followed by insertion of a Foley catheter. The bladder is easily backfilled if a three-way catheter is substituted for the single-port urethral catheter; this option is particularly valuable for patients with prior cesarean deliveries and those at risk for vesicouterine adhesion.

In the absence of clear guidelines, surgeons rely on clinical judgment and experience to choose the incision that provides adequate visualization of the uterus, its attachments, and associated pathology for safe and timely completion of the hysterectomy. Transverse incisions are a traditional and popular choice for abdominal hysterectomy. Surgeons prefer the Pfannenstiel to vertical incisions because of comparatively greater tensile strength. Vertical incisions are less cosmetically appealing to most patients but have the advantage of reduced blood loss and postoperative pain compared to transverse incisions. The greatest benefit of vertical incisions is the relative ease of expanding the surgical field. Maylard and Cherney incisions provide excellent access to the pelvis and midabdomen and may be used by experienced surgeons in place of

vertical incisions for patients with relatively large uteri. Incisions for gynecologic surgery are reviewed in Chapter 8.

Once the abdomen is open, the surgeon proceeds with systematic exploration of the pelvis and abdomen to assess anatomy and the extent of pathology. Particular attention is paid to palpation of the reproductive organs and their relationship to the pelvic sidewalls, bladder, omentum, sigmoid colon, small bowel, and appendix. The remainder of the abdomen (including the aorta, kidneys, pancreas, stomach, liver, and gallbladder) is also examined. The surgical table is adjusted to the Trendelenburg position and the operating room lights aligned for optimal exposure. The combination of standard operating surgical lights and retractors typically achieves satisfactory exposure during abdominal hysterectomy. In some cases, such as in patients with a deep pelvis, the use of headlamps and/or lighted retractors is particularly helpful.

A wide array of self-retaining retractors are available, which meet the anatomic requirements of most patients. The O'Connor O'Sullivan, Balfour, and Kirschner retractors are popular choices during abdominal hysterectomy for benign disease, and the choice is frequently a matter of personal preference. Available retractors (with interchangeable blades of various lengths, shapes, and sizes), when chosen appropriately, optimize surgical exposure. Insertion of the Balfour retractor with the upper arm and adjustable malleable attachment provides an excellent view of the surgical field and is easy to introduce even when the uterus is quite large. The ring of the O'Connor O'Sullivan limits the expanse of the operating field thus is most useful in patients with small uteri and minimal pathology. Alternatively, the Bookwalter retractor rings are ideally suited for exposure during delivery of large uteri through long vertical incisions because they are forged in various sizes. Surgeons frequently choose the Bookwalter when operating on obese patients.

Newer panniculus retractors consist of sheets of adhesive-backed plastic designed to elevate the pannus cephalad. These devices have gained popularity for cesarean delivery, but there are no data about their use during hysterectomy. A panniculus elevator would not replace a self-retaining retractor but could theoretically make retractor placement easier.

Wound protector-retractor devices are designed to cover and protect wound edges from contamination. These are associated with a significant decreased surgical site infection rate after colorectal surgery, but their impact on hysterectomy-associated surgical site infection rates is unknown.

After placement of the self-retaining retractor, the bowel is packed loosely into the upper abdomen with moist laparotomy packs, and the upper retractor blades are secured. Right-handed primary surgeons should position themselves on the patient's left so that the dominant hand easily reaches into the pelvis. Traction applied to the fundus elevates the uterus from the pelvis, improves visualization, and facilitates dissection throughout the procedure. Some surgeons prefer to place a Massachusetts (Lahey thyroid) clamp on the most cephalad aspect of the fundus to raise the uterus from the pelvis, but the toothed grip of the clamp can cause bleeding throughout the case. Kocher clamps, which incorporate the utero-ovarian ligament, fallopian tube, and proximal round ligament at each cornu, are preferred because they provide ample traction and prevent back bleeding (**BOX 23.1**).

## BOX 23.1 STEPS IN THE PROCEDURE

### Abdominal Hysterectomy

- Secure and transect round ligament. This allows access to the retroperitoneum for identification of the pelvic ureter and for isolation of the ovarian pedicles.
- Incise anterior leaf of the broad ligament to begin vesicouterine dissection.
- Open the posterior leaf of the broad ligament and identify the ureter.
- Isolate and clamp the infundibulopelvic ligament (if bilateral salpingo-oophorectomy is planned) or utero-ovarian ligament (if ovaries will be retained).

- Transect infundibulopelvic ligament (if bilateral salpingo-oophorectomy is planned) or utero-ovarian ligament (if ovaries will be retained).
- Create vesicouterine space and mobilize the bladder off the cervix and proximal vagina.
- Isolate the uterine artery and vein. This will minimize tissue in uterine vascular pedicle and will also lateralize the ureters. However, when skeletonizing these vessels, efforts to completely unsheathe the vessels may result in accidental vascular injury or transection.
- Clamp, incise, and ligate the uterine artery and vein to achieve hemostasis.
- If supracervical hysterectomy is planned, amputate the uterine corpus. This is also an intermediate step in total hysterectomy for benign disease if the uterus is bulky (eg, if visualization of the cervix would be facilitated by removing the fundus).
- Secure and divide the cardinal ligaments.
- Excise the cervix from vaginal attachments.
- Close the vaginal cuff.
- Universal cystoscopy improves the early detection of urinary tract injury. Surgeons should have a low threshold for evaluation of the urinary tract when there is concern for injury.

If salpingectomy is planned, the ampullary portion of the fallopian tube is grasped with a Babcock clamp and elevated. The surgeon isolates the small vessels in the mesosalpinx with either electrocautery or Metzenbaum scissors and secures the peritoneal attachment close to the inferior margin of the tube with Kelly clamps. Each pedicle is then transected and ligated with 3-0 delayed absorbable suture. Alternatively, the surgeon may opt to divide the fallopian tube and mesosalpinx with a vessel-sealing device placed so that the tips of the concave edge of the device abuts the inferior aspect of the tube. Care should be taken to ensure that the entire

fimbriated distal portion of the tube is freed/removed. The tubes can be left attached at the cornual end and removed *en bloc* with the uterus.

The hysterectomy begins with division of the round ligaments. Round ligaments are generally reliable anatomic landmarks, even in the face of significant pathology and anatomic distortion. While an assistant provides contralateral uterine displacement, the entire thickness of the stretched round ligament is grasped with Russian forceps at a point midway between the cornu and sidewall. Next, the entire ligament (and the underlying Sampson artery) is transfixed with a 1-0 or 0 delayed absorbable suture to ensure hemostasis. The assistant tags the suture tails with a hemostat, which is used to provide traction during round ligament transection and broad ligament dissection. A second transfixion suture on the medial pedicle is unnecessary when the proximal round ligament is clamped at the cornu. With the assistant towing the fundus to the opposite side of the pelvis, the tagged round ligament is retraced laterally. The surgeon transects the entire round ligament with electrocautery or scissors **(FIG. 23.1**). The purpose of this step is to gain retroperitoneal access and begin vesicouterine or posterior broad ligament dissection.

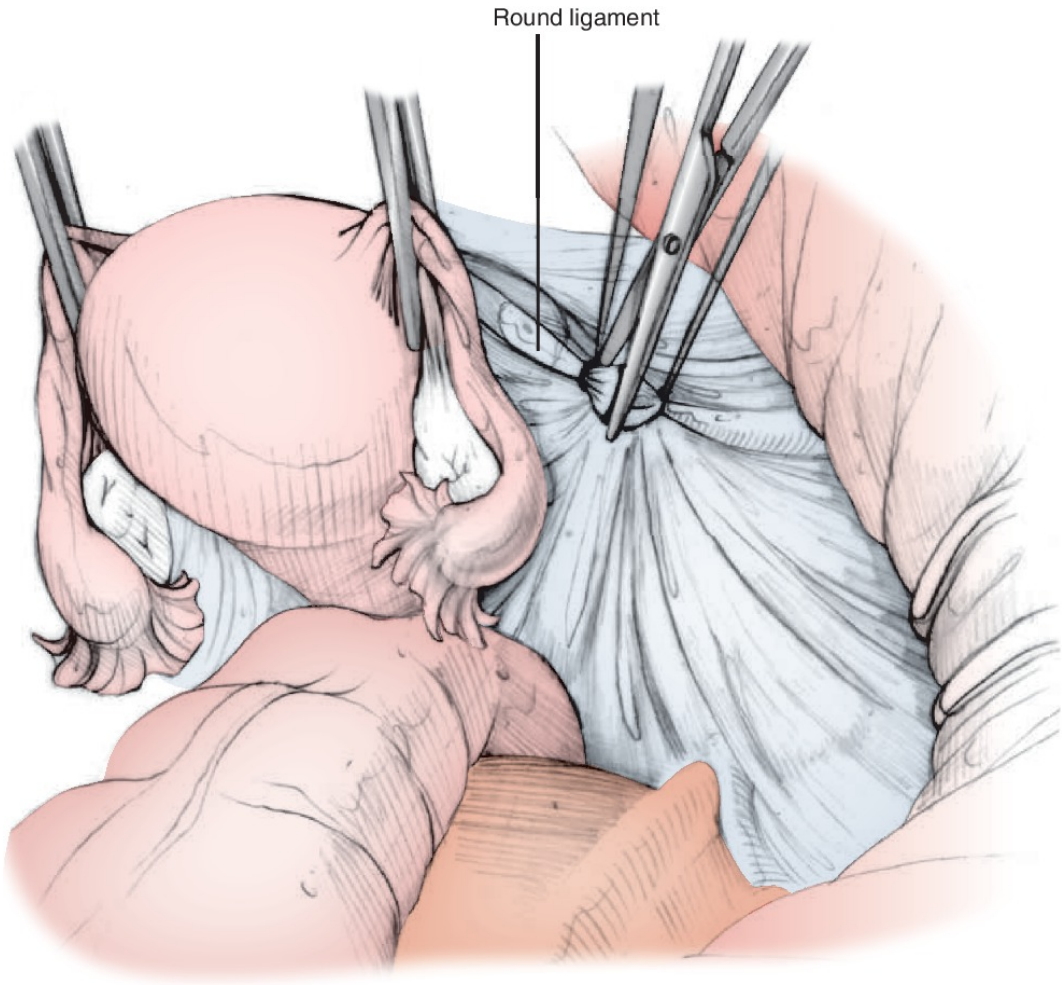
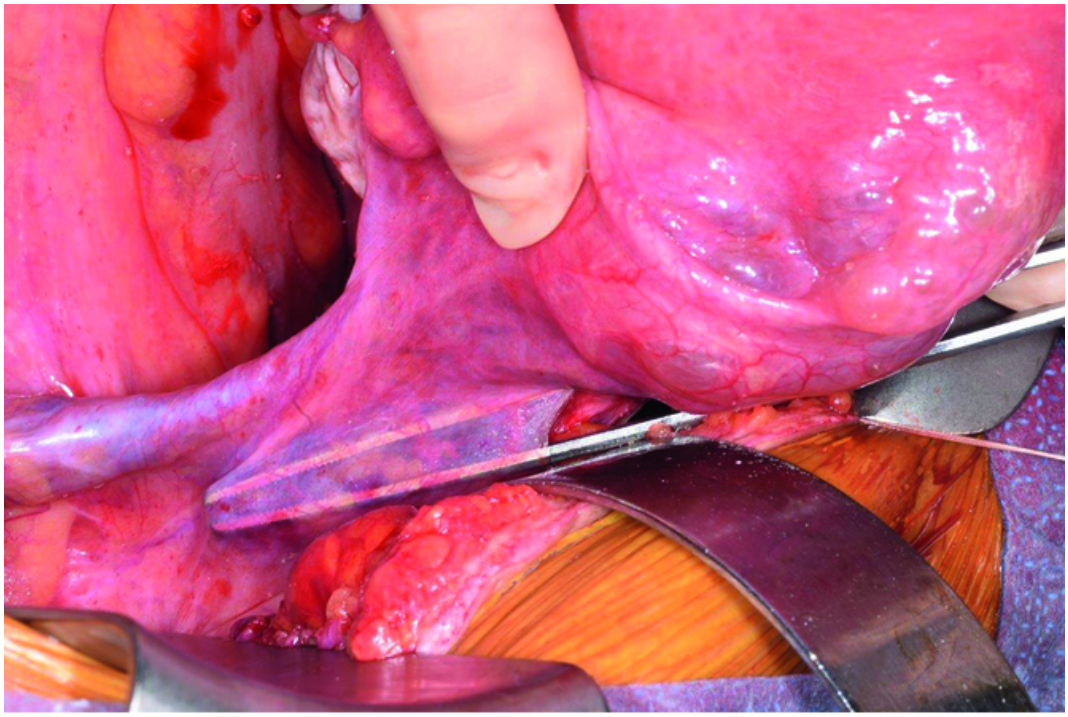



**FIGURE 23.1** The technique of abdominal hysterectomy begins with dividing the round ligament. The ligament is ligated with transfixion sutures and cut. The broad ligament is opened. (When the round ligament is contained in a clamp at the cornu, a second ligature on the medial pedicle, as shown here, is optional.)

Maintaining traction on the lateral segment of the round ligament in a lateral and cephalad direction, the anterior leaf of the broad ligament is dissected from the incised round ligament, toward the

vesicouterine peritoneal fold. This can be done with Metzenbaum scissors or electrocautery. The incision is extended to the midline; contralateral incision of the vesicouterine peritoneum is completed after transection of the contralateral round ligament.

Next, using Metzenbaum scissors or electrocautery, the broad ligament incision is extended posterolaterally, from the point of round ligament transection, parallel and lateral to the infundibulopelvic (IP) ligament, to the pelvic sidewall (**FIG. 23.2**). This step is easier when the assistant directs the uterus toward the patient's opposite thigh and with traction on the lateral round ligament pedicle directed inferiorly. After the peritoneum has been opened, the operator separates the underlying areolar connective tissue carefully with an index finger, Yankauer suction device, or the blunt end of forceps to expose the internal iliac artery along the medial aspect of the psoas muscle. The ureter is identified along the medial leaf of the broad ligament (**FIG. 23.3**). If the ureter cannot be identified at this site, the surgeon should continue the dissection cephalad (to the bifurcation of the common iliac artery) to find the ureter as it crosses the pelvic brim, then follow its course as it traverses the broad ligament in the pelvis. Prevention of urogenital injury requires detailed knowledge of pelvic anatomy, and pelvic surgeons should take the time to master and teach retroperitoneal exploration. Comfort with retroperitoneal anatomy is especially important when typical anatomic landmarks are difficult to distinguish. In such cases, careful sharp dissection of scarred tissue reduces the risk of direct injury and devascularization and is preferred to blunt and thermal dissection. Direct observation of ureteral peristalsis provides confirmation of ureteral identification, but sometimes pathology prevents complete visualization. In such cases, the surgeon may be required to rely on palpation (**BOX 23.2**).



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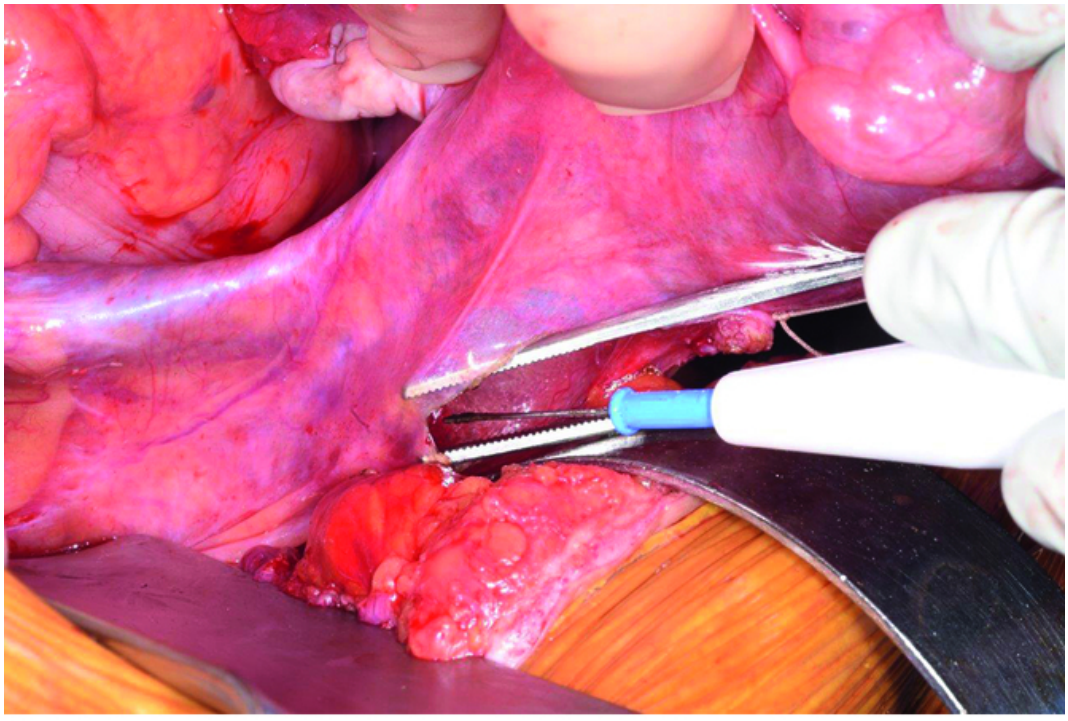


B

**FIGURE 23.2 A.** Undermining and tenting the peritoneum with open vascular forceps lateral

to and parallel to the infundibulopelvic ligament provides a helpful guide, especially for learners. **B.** The peritoneum is then incised with cautery (shown here) or scissors parallel to the IP ligament. (Photograph courtesy of Laurie S. Swaim.)

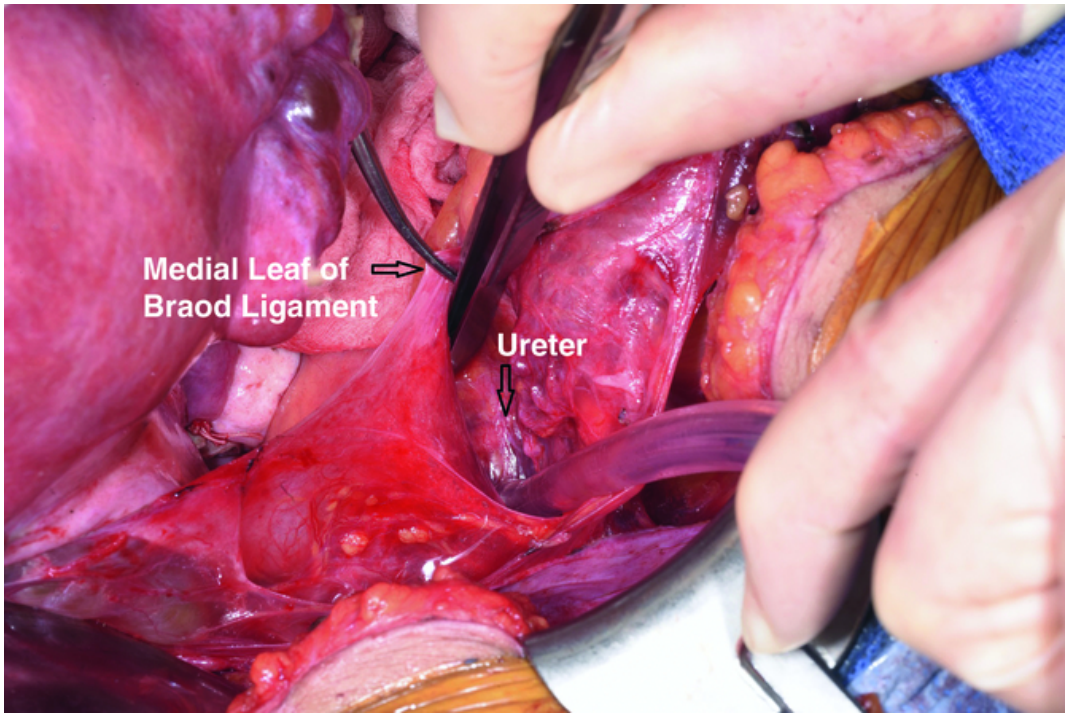



**FIGURE 23.3** Identifying the ureter along the medial leaf of the broad ligament. Once the retroperitoneal space is opened, lean the flat surface of the blunt end of a pair of tissue forceps along the medial leaf of the broad ligament. Draw the forceps end against the broad ligament medially and upward (anterior) to reveal the ureter as it courses toward the

pelvis. (Photograph courtesy of Laurie S. Swaim.)

## BOX 23.2 ADDITIONAL TIPS

### Opening and Dissecting the Retroperitoneum

- **Dissecting the anterior leaf of the broad ligament:** Injection of 20 mL of normal saline beneath the peritoneal reflection may facilitate dissection of the vesicouterine space (but is rarely necessary).
- **Palpating the ureter:** The ureter is most easily palpated by facing the patient's feet. The surgeon on the patient's left places the thumb of the right hand in the left retroperitoneal space and the index finger on the smooth medial peritoneal surface of the broad ligament. The tips of the thumb and index finger pinch the peritoneum deep in the pelvis at the level of the psoas, and the ureter slides through the opposed thumb and finger as the surgeon's hand is elevated toward the ceiling.

If the procedure will include salpingo-oophorectomy, the assistant maintains continuous uterine traction in the opposite and inferior direction. Under direct visualization, the surgeon uses the tips of a right angle clamp to bluntly fracture the medial leaf of the broad ligament under the IP ligament. This is done in an avascular portion of the broad ligament, inferior to the IP ligament and superior to the ureter, in a lateral to medial direction. Some surgeons prefer to identify the avascular space by tenting the tissue with an index finger. Once isolated, a window is created directly over the fingertip with electrocautery or scissors (**FIG. 23.4A**). The Kocher clamp containing the fallopian tube, the utero-ovarian ligament, and the round ligament stump is advanced and redirected so that the tips of the clamp meet in the newly formed window. This clamp both maintains traction and prevents back bleeding from the divided

cornual structures. Isolation of the IP ligament before oophorectomy increases the security of the vascular pedicle and reduces the risk of ureteral injury. Extending the peritoneal incision toward the uterus mobilizes the ovary and creates a shorter distance between the cornu and peritoneal edge.

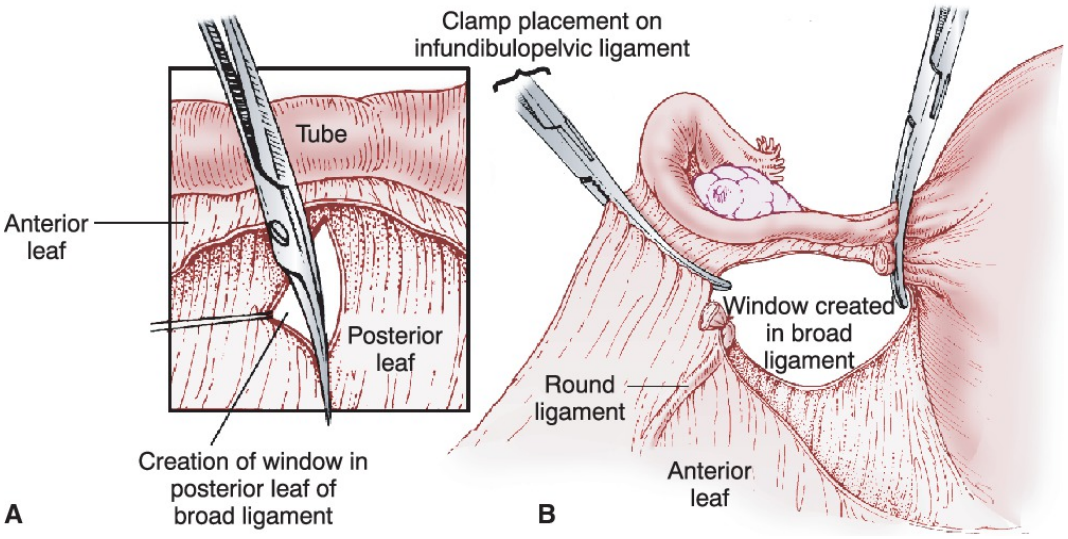
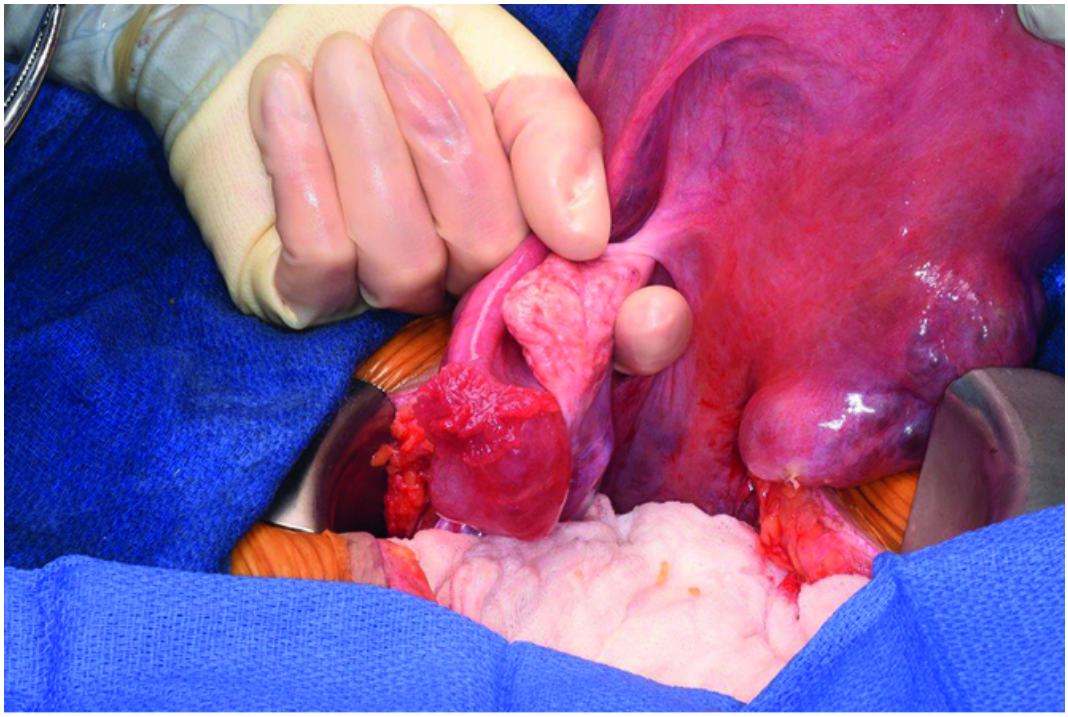



**FIGURE 23.4** **A.** Scissors are used to create a window in the medial leaf of the broad ligament. The window is then extended toward the uterus so that the clamp containing the utero-ovarian ligament and round ligament stump can be repositioned with the tip in this window. **B.** The infundibulopelvic ligament is secured with a Heaney clamp (concave side of the clamp toward the pelvis). A Kocher or other sturdy clamp the drawing does not depict a Kocher clamp containing the fallopian tube, utero-ovarian ligament, and the round ligament stump prevents back bleeding from

the divided cornual structures and also provides traction on the uterus.

Next, the IP ligament is secured with a Heaney clamp placed with the concave side of the clamp toward the pelvis (**FIG. 23.4B**). Forceful clamp advancement can cause tissue trauma as the clamp teeth rake against the pedicle and is best avoided. If the Kocher clamp on the cornu was not redirected to prevent back bleeding, a second clamp with similar curve is placed through the same peritoneal window (closer to the uterus). The IP ligament is then divided between the two clamps with Mayo scissors, and the pedicle secured with a freehand 0-Vicryl tie while "flashing" the clamp. This is followed by a transfixion stitch of 0-Vicryl. The transfixed stitch is placed distal to the freehand suture to prevent vascular injury and hematoma. Some surgeons substitute vessel-sealing devices for traditional clamps for this step. Floppy adnexa may be fixed to the specimen with suture or excised.

If salpingo-oophorectomy is not planned (eg, the ovaries are left *in situ*), a similar technique is followed, but the window in the leaf of the broad ligament is made medial to the ovary. Slipping the index finger of the nondominant hand through the peritoneal window isolates the utero-ovarian pedicle (**FIG. 23.5A**) and serves as a smooth guide for Heaney clamp advancement as described above (**FIG. 23.5B**). Again, the surgeon readjusts the Kocher containing the round ligament stump, utero-ovarian ligament, and fallopian tube so that its tips meet in the space, which serves as a back clamp. The pedicle is transected with Mayo scissors and secured with a freehand 0-Vicryl tie and followed by a 0-Vicryl transfixion stitch (**FIG. 23.6**). After hemostasis is assured, adnexa that obscure the visual field may be loosely packed above the pelvic brim. Next, these steps are completed on the contralateral side.



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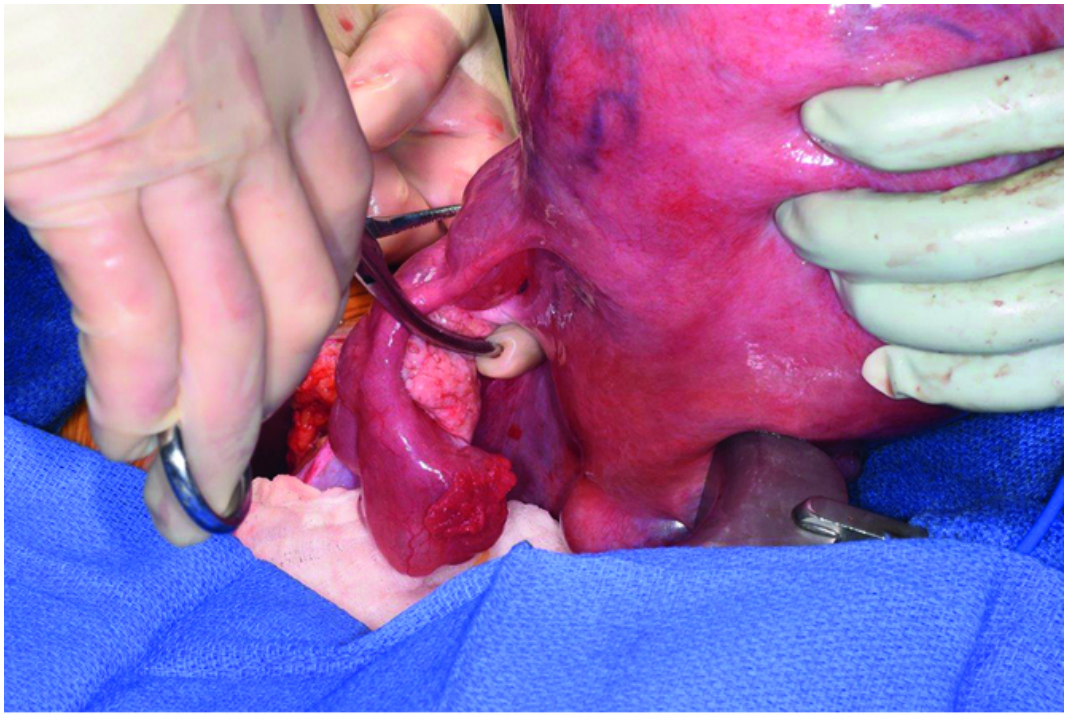

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**FIGURE 23.5** **A.** When securing the IP or utero-ovarian ligament, the surgeon first

places the index finger through the window in the broad ligament, serving as a guide for clamp placement and isolating the IP or utero-ovarian pedicle as seen here. **B.** Next, a curved clamp is guided into the window in the broad ligament. This is most easily done by orienting the clamp, so the heel faces the lateral pelvis, opening the clamp wide enough to encompass the IP or utero-ovarian ligament and fallopian tube complex, and resting the tip of the posterior blade on the tip of the index finger. While maintaining this relationship, the index finger is drawn back through the peritoneal opening until the tips clear the tissue and the entire pedicle is contained and secure the clamp. (Photograph courtesy of Laurie S. Swaim.)

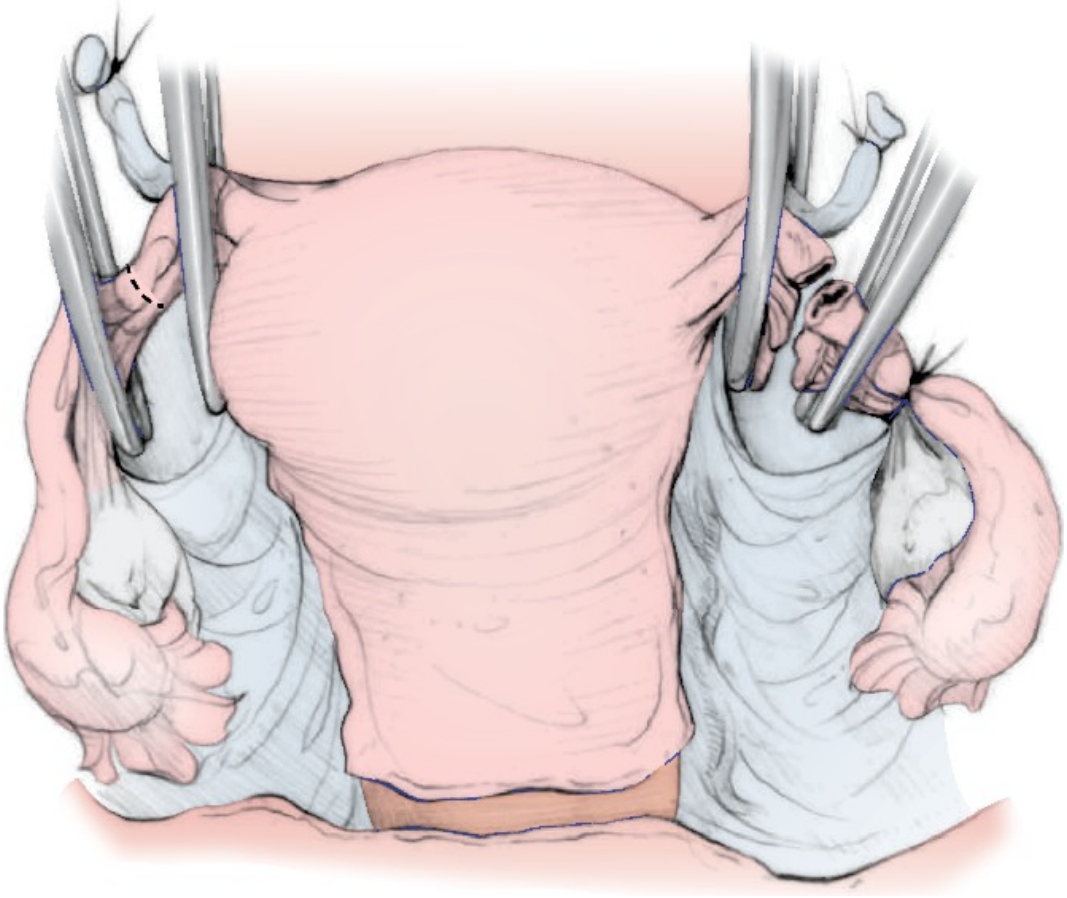

**FIGURE 23.6** The utero-ovarian pedicle is transected with Mayo scissors and secured with a freehand 0-Vicryl tie. The free tie is followed by a 0-Vicryl transfixion stitch, which will be placed distal to the free tie.

The incision of the vesicouterine peritoneal reflection is completed sharply or with electrocautery. The bladder is then dissected off the cervix. The uterus is firmly elevated out of the pelvis as the avascular space between the posterior bladder and anterior cervix is dissected with Metzenbaum scissors (**FIG. 23.7**). Keeping to the middle portion of the cervix when feasible prevents accidental interruption of lateral cervical vasculature. However, when dense midline adhesions are present, lateral development of the correct tissue plane is sometimes

preferred. The “snip-push-spread” technique (**FIG. 23.8**) minimizes trauma, facilitates entry into the correct tissue plane, and is especially useful when scarring is present after cesarean delivery. Blunt dissection of the vesicouterine space is acceptable when the bladder is nonadherent, although sharp dissection of this space is preferred.

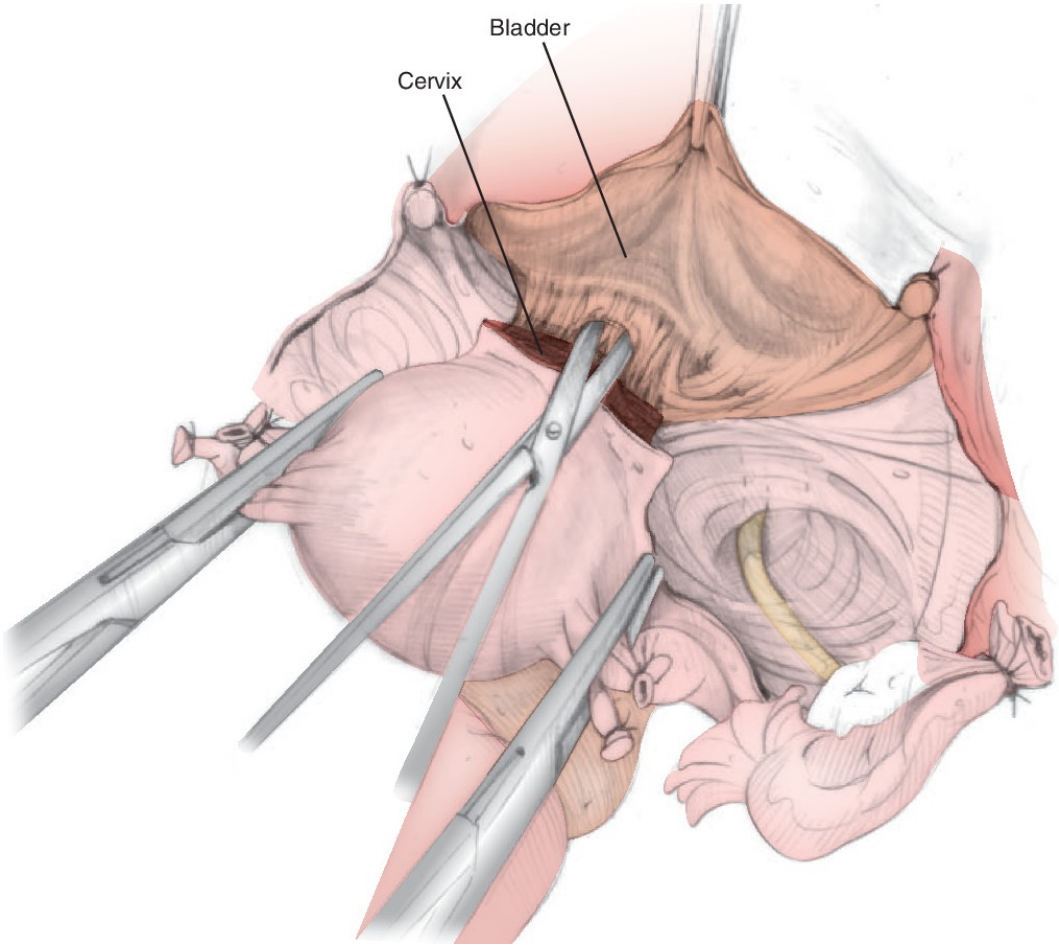


**FIGURE 23.7** The bladder is mobilized inferiorly by sharp dissection away from the cervix. To avoid unnecessary bleeding, this step may be done in stages as necessary.

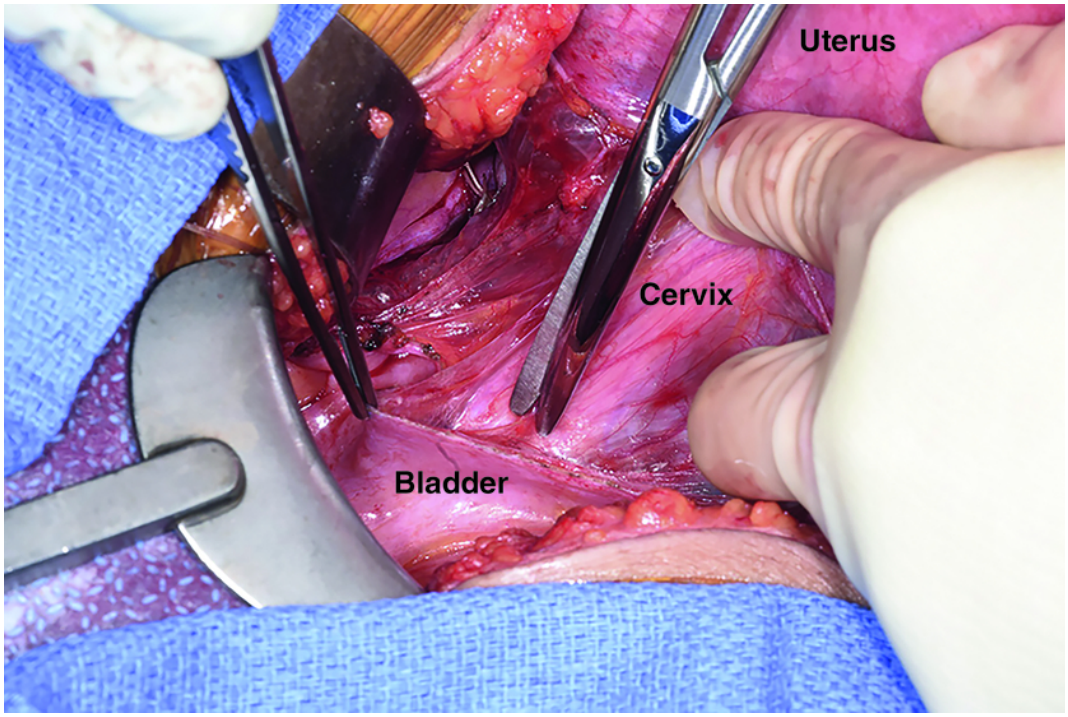


**FIGURE 23.8** While the assistant retracts the bladder, the surgeon's left hand (in this case) provides traction on the cervix to gain the appropriate angle to identify the vesicouterine space. To dissect the bladder off the cervix and anterior vagina, the cut edge of the bladder peritoneum is grasped with vascular forceps or a Sarot clamp in the midline. Resting the tips of the scissors on the anterior cervix, the surgeon snips a few millimeters of tissue overlying the cervical fascia. Without removing the scissors, the surgeon immediately advances or "pushes" the tips of the closed scissors 3-4 mm, then spreading the blades 3-4 mm in the same plane. Note

that the tips of the scissors rest on the anterior cervix as dissection proceeds. (Photograph courtesy of Laurie S. Swaim.)

Achieving the appropriate instrument angle for bladder dissection can be challenging particularly when fibroids protrude into the operative field. Anchoring a towel clip to an anterior intramural fibroid, or manual posterior and cephalad uterine displacement are examples of techniques that often enhance visualization and provide room for dissection. In some patients, vesicouterine scarring is so severe that the demarcation between the bladder and the uterine serosa is unclear. Surgeons may try retrograde bladder distention to identify the superior margin of the bladder, but unless the uterus is pulled sharply cephalad, the expanded bladder is likely to cover the field. Division of adhesion between small hemoclips is a useful technique for the separation of dense adhesions between the bladder and uterus.

For total hysterectomy, the bladder should be dissected completely off the anterior cervix, below the level of the external cervical os. Once accomplished, the risk of bladder injury is low, and the uterine artery and vein can be uncovered from surrounding connective tissue. However, when visualization is limited by an enlarged uterus, the surgeon may choose to separate the bladder and the cervix in a stepwise fashion. In such cases, the vesicouterine dissection is advanced to just below the level of the internal os so that the uterine vessels may be safely identified and secured. Once accomplished, amputation of the uterine fundus provides ample exposure to finish the dissection (**BOX 23.3**).

## BOX 23.3 ADDITIONAL TIPS

### Bladder Dissection

- **Incision of the vesicouterine peritoneum:** If scarring makes identification of the superior margin of the bladder impossible, a

uterine sound inserted through the urethra to the top of the bladder can delineate the superior margin of the bladder and identify a suitable area for dissection above the sound tip.

- **Dissecting the bladder off the cervix bluntly:** In order to proceed bluntly, elevate the peritoneal edge of the bladder with forceps and insert the second and third fingertips behind the bladder and gently spread over the cervix until the dissection is complete. Alternatively, grip the cervix with one hand, and gently peel the bladder from the cervix with the thumb, using a downward sweeping motion against the cervix.

The next step is skeletonization of the uterine arteries. This step reveals the uterine artery and vein at the level of the internal os, minimizes vascular pedicle tissue bulk, and lateralizes the ureters (**FIG. 23.9A**). Skeletonization is best performed while the assistant provides traction on the fundus toward the ceiling with a slight lateral tilt to the opposite side. The most efficient way to unroof the uterine vessels is to begin the dissection immediately lateral to the uterus. Grasping the edge of the connective tissue near the uterus enables the surgeon to use longer and fewer sweeping motions that dissect a greater volume of tissue as compared to bites started more laterally. Complete unsheathing of the uterine artery and vein is not necessary, and excessive dissection can result in accidental vascular injury or transection. Once skeletonization is complete, incision of the posterior peritoneum medially toward the uterosacral ligaments is performed; separation of the rectum from the vagina is only required if adherent to the posterior cervix.

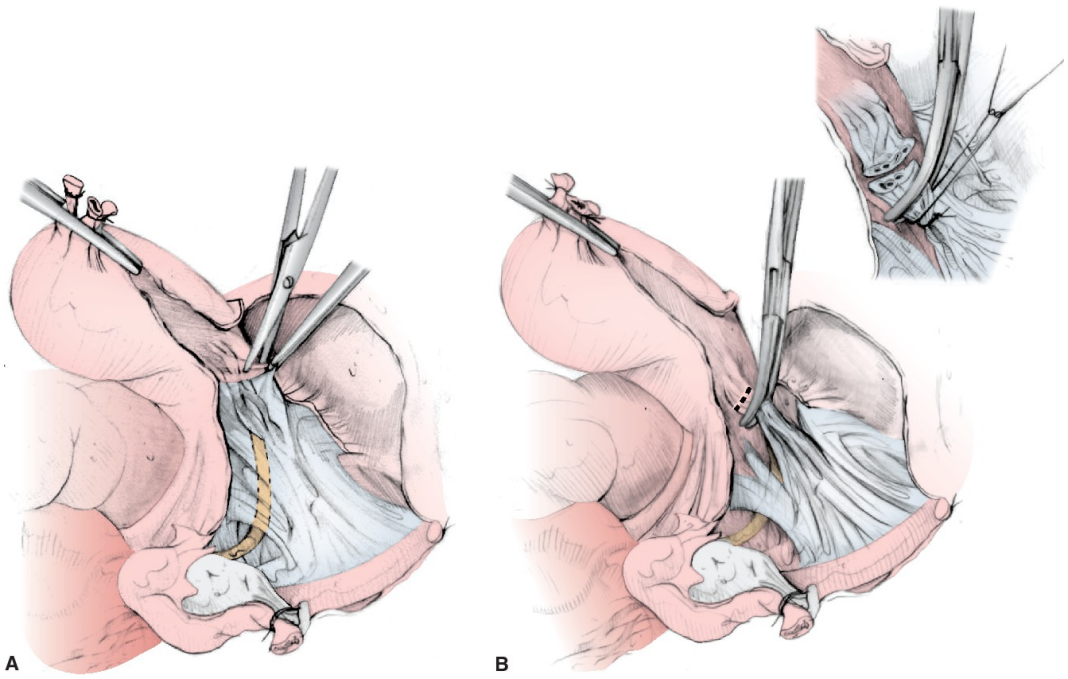


**FIGURE 23.9** **A.** The uterine vessels are skeletonized. **B.** A curved Heaney clamp is used to clamp the uterine vessels immediately adjacent to the uterus at the level of the internal os. Note the course of the ureter passing under the uterine vessels. As shown in the **inset**, the uterine vessels are ligated by a suture ligature. This pedicle is often doubly ligated (even when singly clamped).

When securing the uterine vessels, the surgeon should elevate the uterus to facilitate snug and proper clamp placement. Once the uterus is on traction and is positioned correctly, a sturdy and slightly curved instrument such as the Heaney or Masterson clamp can be placed across the uterine vessels. The tip of the clamp should lie perpendicular to the uterine vessels with its tips situated closely against the lateral border of the uterus at the level of the internal cervical os (**FIG. 23.9B**). Some surgeons prefer to apply two clamps

to the uterine vascular pedicle; however, this step is not universal. If control of back bleeding is needed, place an additional clamp medial to the first, with space available for division of the pedicle. Divide the pedicle with Mayo scissors or a knife, and secure the pedicle with a 0 delayed absorbable suture placed under and at the tip of the Heaney clamp (**FIG. 23.10**). The needle size should be determined by the space available and the size of the pedicle. The assistant opens and removes the clamp slowly as the surgeon cinches the first knot throw. To reduce the amount of instruments in the field, the tissue in the back clamp may be ligated and the clamp removed. A similar procedure is carried out on the opposite side (although a back clamp on the second side is unnecessary unless the uterus is large and significant back bleeding is anticipated) (**BOX 23.4**).

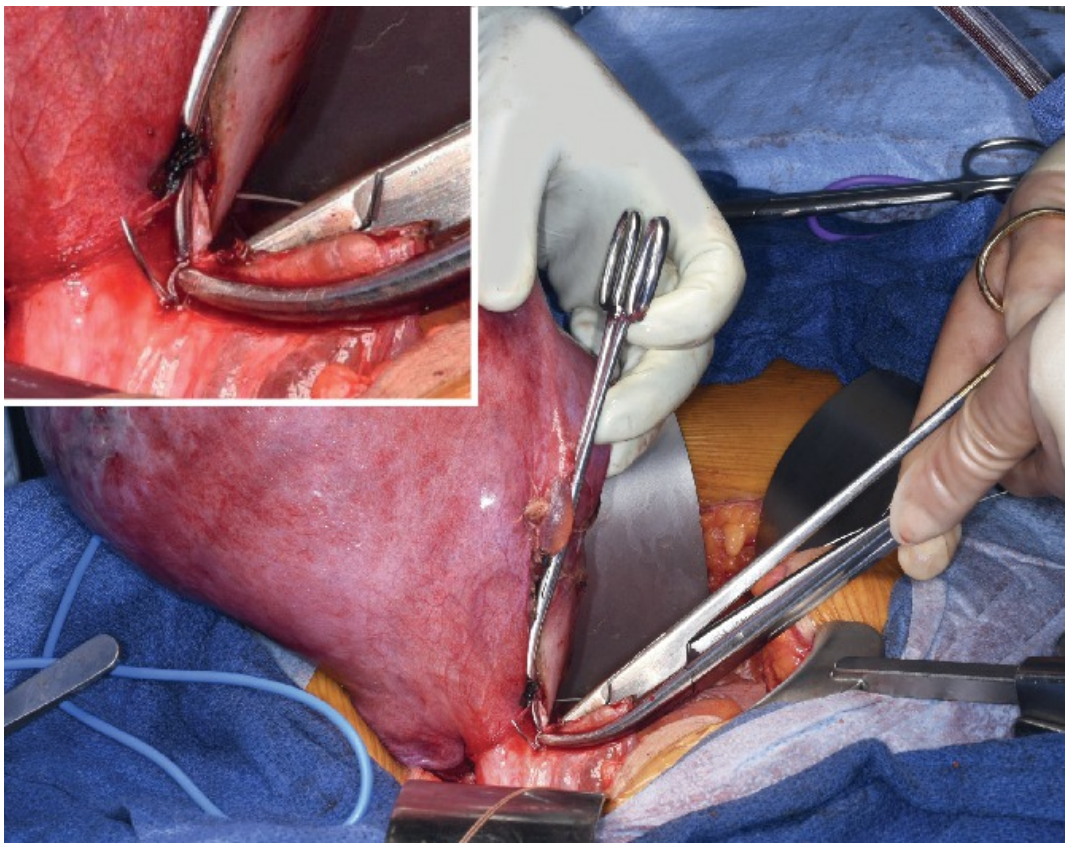

**FIGURE 23.10** When ligating the uterine vessels, the suture is placed at the inferior tip

of the curved clamp. (*Inset* shows detail.) The ligature is tied under the clamp as an assistant opens and withdraws the clamp. (Photograph courtesy of Laurie S. Swaim.)

## BOX 23.4 ADDITIONAL TIPS

### Clamp Placement

- **Uterine artery pedicle:** To situate the clamp and secure the uterine vessels, the primary surgeon elevates the uterus with the nondominant hand toward the ceiling and slightly forward. In order to ensure appropriate placement, open a Heaney clamp fully with the dominant hand and lay the open face of the posterior blade against the posterior uterus at the appropriate level. Maintain the relationship of the posterior blade and the tissue, and rock the uterus posteriorly. Forward pressure and slight rotation of the dominant hand helps to preserve the location of the posterior blade against the uterus. While the assistant retracts the bladder inferiorly, swing the anterior blade so its tips surround a few millimeters of the lateral cervix at the internal os, and completely close the clamp. While closing the clamp, the Heaney slides off the lateral cervix so that the tips of the clamp are immediately adjacent to the uterus.
- **Clamping across the vaginal apex:** If the tips of two curved clamps are not touching, leave a space of 1 cm or more between the clamps. The space between clamps should be wide enough to allow the surgeon to confidently identify and include the edges of the anterior and posterior vaginal mucosa in the cuff.

Safe amputation of the uterine fundus is possible once the uterine vascular pedicles are secured. This step is an integral part of supracervical hysterectomy (see following section), and this simple

step may also be particularly useful in total hysterectomy when the uterus is large and obstructs the view of the deep pelvis. A firm compressive grasp of the exposed surface of the cervical stump with a Lahey thyroid clamp provides excellent traction and contributes to hemostasis during the remaining steps of the hysterectomy.

The cardinal ligaments are divided next. The large tooth of the Ballantyne clamp anchors firmly to the posterior cervix and is ideally suited for securing the remaining lateral cervical attachments. The surgeon should secure the superior cardinal ligaments by introducing the clamp between the uterine vascular pedicle and lateral cervix nearly parallel to the length of the cervix. The Ballantyne clamp is closed slowly, so the lateral cervical tissue is pinched and the clamp tip lies snugly against the cervix (**FIG. 23.11**). Mayo scissors or a long-handled knife may be used to divide the tissue. Avoid dissection of tissue past (medial) to the tip during this step, which can be associated with shearing of tissue and avoidable bleeding. To free residual fibers of cardinal ligament without traveling past the clamp tip, rest the belly of a knife blade at and perpendicular to the very tip of the Ballantyne. While holding the blade steady, gently rotate the clamp clockwise and counterclockwise to free the residual fibers without traveling past the knife tip. The pedicle is transfixed by introducing a suture ligature of 0 delayed absorbable suture at and under the tip of the Ballantyne. The use of the Heaney suture technique when the pedicle measures greater than a centimeter avoids slippage of the upper portion of the transected ligament. Sequential bites of cardinal ligaments are obtained in a similar fashion on each side of the cervix until the level of the external cervical os is reached. Each successive clamp is placed medial to the prior pedicle, so that the tips are on the lateral cervix, and back of the clamp lies next to the prior knot. Prior to each clamp placement, the surgeon should assess the position of the bladder and rectum, advancing the dissection of these structures if needed. Depending on anatomy and visualization, the surgeon can proceed with a series of tissue “bites” on one side of the cervix or may switch from side to side. In some patients, the superior aspect of the uterosacral ligaments are easy to hook with the tooth of the Ballantyne and may be incorporated into the final cardinal pedicle.

Alternatively, the uterosacral ligaments may be contained in a clamp with the remaining lateral attachments during cervical amputation (**BOX 23.5**).

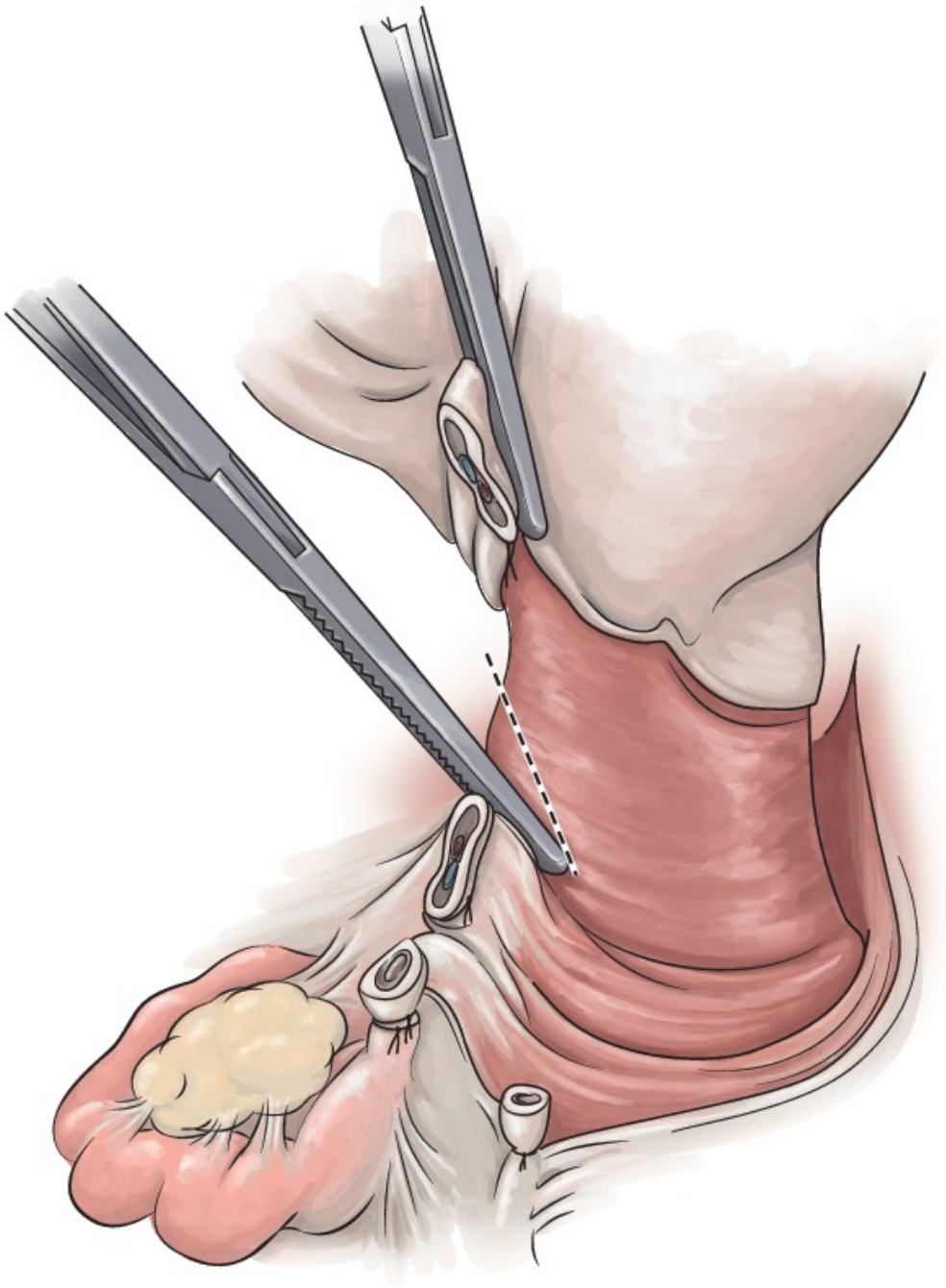

**FIGURE 23.11** After the uterine artery and vein have been ligated, the remaining lower portion of the cardinal ligament is clamped with a series of straight clamps. The tips are placed on the edge of the cervix and the back of the jaw immediately adjacent to the previous pedicle.

## BOX 23.5 ADDITIONAL TIPS

### Cardinal Ligament Pedicles

- To transect the clamped cardinal ligament pedicles, outline a wedge-shaped pedicle by drawing a knife blade medially from the tip to heel of the clamp on each side of the ligament. Using the outline as a guide, alternate incisions from anterior and posterior directions until the pedicle is free.
- As the cardinal ligament pedicles are sutured with a transfixion stitch, the surgeon should cinch the suture directly along the back of the clamp so the knot lies squarely over the cut tissue without including lateral pedicles.

Once the cardinal ligaments have been divided to the level of the vaginal fornices bilaterally, the uterus can be removed. A closed technique is typically preferred. With firm uterine traction, from the lateral aspect of the cervix, place a Heaney clamp directly under and tightly abutting the cervix. Advance the clamp to include anterior and posterior vagina to the heel of the clamp, and place a second clamp on the contralateral side. The tips of each Heaney should ideally touch on the anterior and posterior surfaces of the superior vagina, which prevents slippage and bleeding of the cut edge of vaginal mucosa (**FIG. 23.12**). Cut directly over each clamp with a Mayo scissors to separate the cervix and vagina, and pass the specimen

off the surgical field. A figure-of-8 suture can be placed at this time to bring together the vagina in the midline, or this suture can be placed after the pedicles containing the uterosacral and cardinal ligaments are sutured and tied. This figure-of-8 suture must include the full thickness of vaginal mucosa. The hysterectomy is completed as the surgeon secures each lateral pedicle with a 0 delayed absorbable suture in a Heaney fashion, making sure to gain purchase of the uterosacral ligament in the second bite.

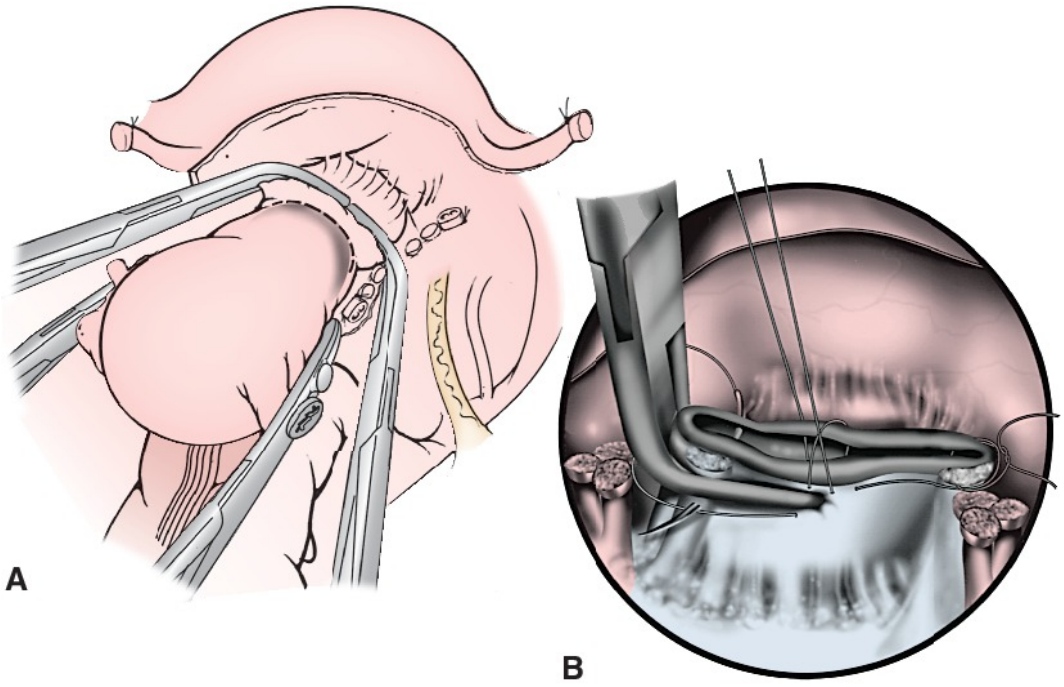


**FIGURE 23.12** **A:** After checking to be sure the bladder and rectum are clear, the vagina is cross-clamped with curved Heaney or Zeppelin clamps just below the cervix (*dotted line*). The vagina is divided just above the clamps (with a knife or angled scissors). The lateral pedicles are closed with a Heaney suture ligature, incorporating the uterosacral ligament in the closure. **B:** In addition, the

central portion of the cuff is closed with one or more figure-of-8 sutures.

This closed-cuff technique is not always possible when the cervix is wide or bulbous. Also, clamps placed under a protruding cervix or prolapsing fibroid increase the chance of vaginal shortening. In these situations, an open technique is preferred. The anterior vagina is grasped with a Kocher or Allis clamp 5-10 mm below the cervicovaginal junction. Using this clamp to elevate the vaginal wall, the surgeon enters the vagina sharply (with a knife) above the level of the clamp. A sponge stick or other blunt instrument introduced into the anterior vaginal fornix can be a helpful guide when the junction is not obvious. Once entered, the full thickness of the vaginal edge should be grasped with a Kocher. The surgeon can then excise the cervix circumferentially with the Jorgenson scissors, being careful to remain above the lateral pedicles. The intravaginal blade of the Jorgenson scissors should follow the fornix as closely as possible to the cervix to prevent vaginal shortening. As the vagina is divided from the cervix, additional Kocher clamps are placed on the full thickness of the anterior mid, lateral, and posterior mid vaginal mucosa. Inclusion of the posterior peritoneum edge in the clamp facilitates inclusion into the cuff during closure. Lateral vaginal supports are contained in separate “angle” sutures. If the surgeon secures one of the angles with a long suture, this suture can be used to close the cuff toward the opposite side (with a running locked technique). Alternatively, after the angle sutures are tied, the cuff can be closed with a series of figure-of-8 sutures.

If supracervical hysterectomy is planned, transection of the cardinal ligaments to the midcervix is sufficient. The bladder is then advanced to 1 cm below the planned level of cervical transection. A straight clamp is placed at the insertion of each cardinal ligament for traction. Using electrocautery or a long-handled knife, an inverted cone of cervical tissue is incised so that the tip of the cone ends within the cervical canal (**FIG. 23.13**). Some surgeons excise a second small disc of endocervix for frozen section to ensure complete endometrial resection. The anterior and posterior cervix

are then reapproximated using delayed absorbable suture in an interrupted or figure-of-8 fashion (**FIG. 23.14**). A smaller-caliber delayed absorbable suture may be used to reperitonealize the stump with anterior and posterior peritoneum but is not required.

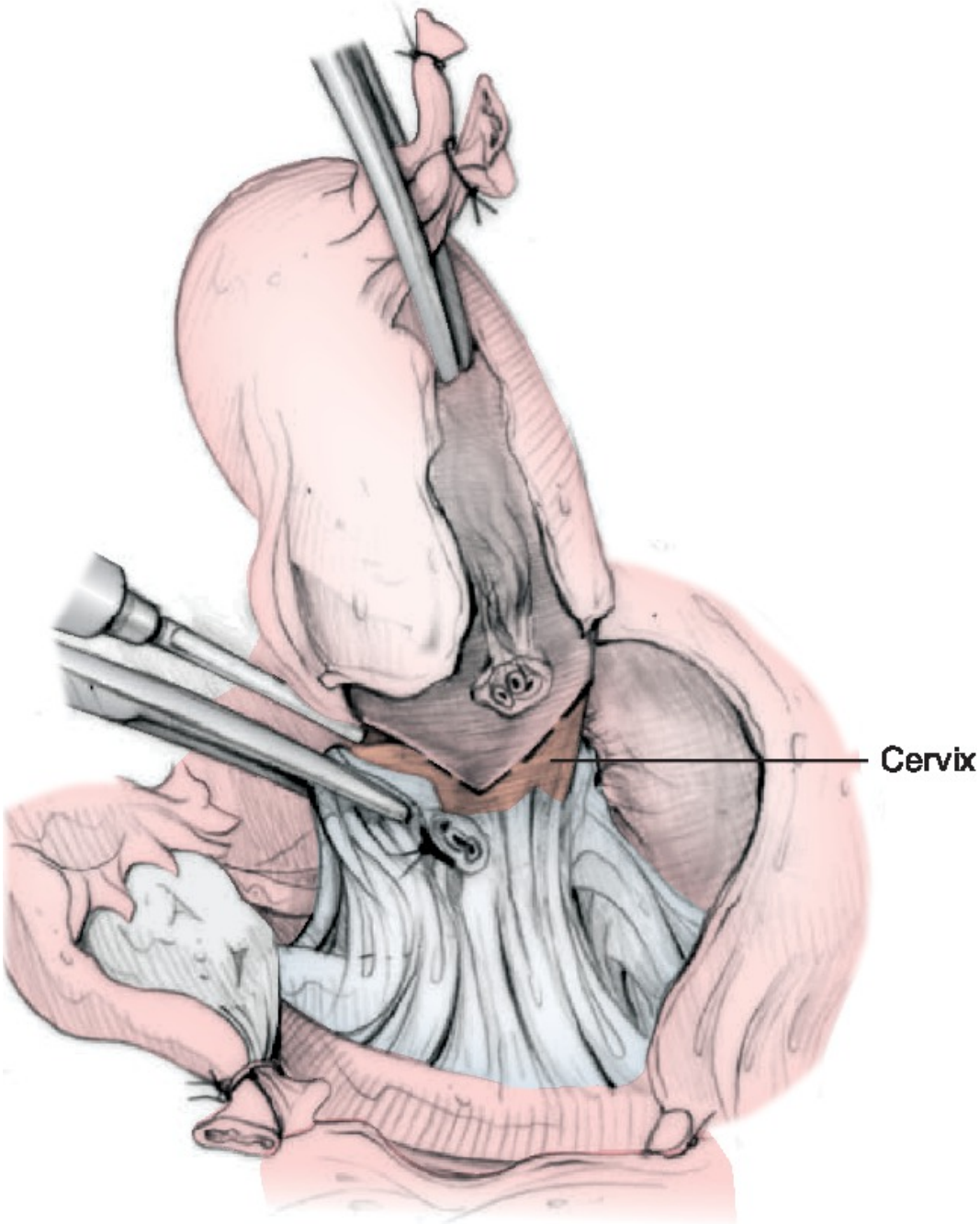

**FIGURE 23.13** Subtotal or supracervical hysterectomy. After the uterine vessels have been ligated, the fundus is amputated using the electrocautery in a shallow cone-shaped technique. As shown here, straight clamps at the insertion of each cardinal ligament can be used to stabilize the cervical stump and for traction.

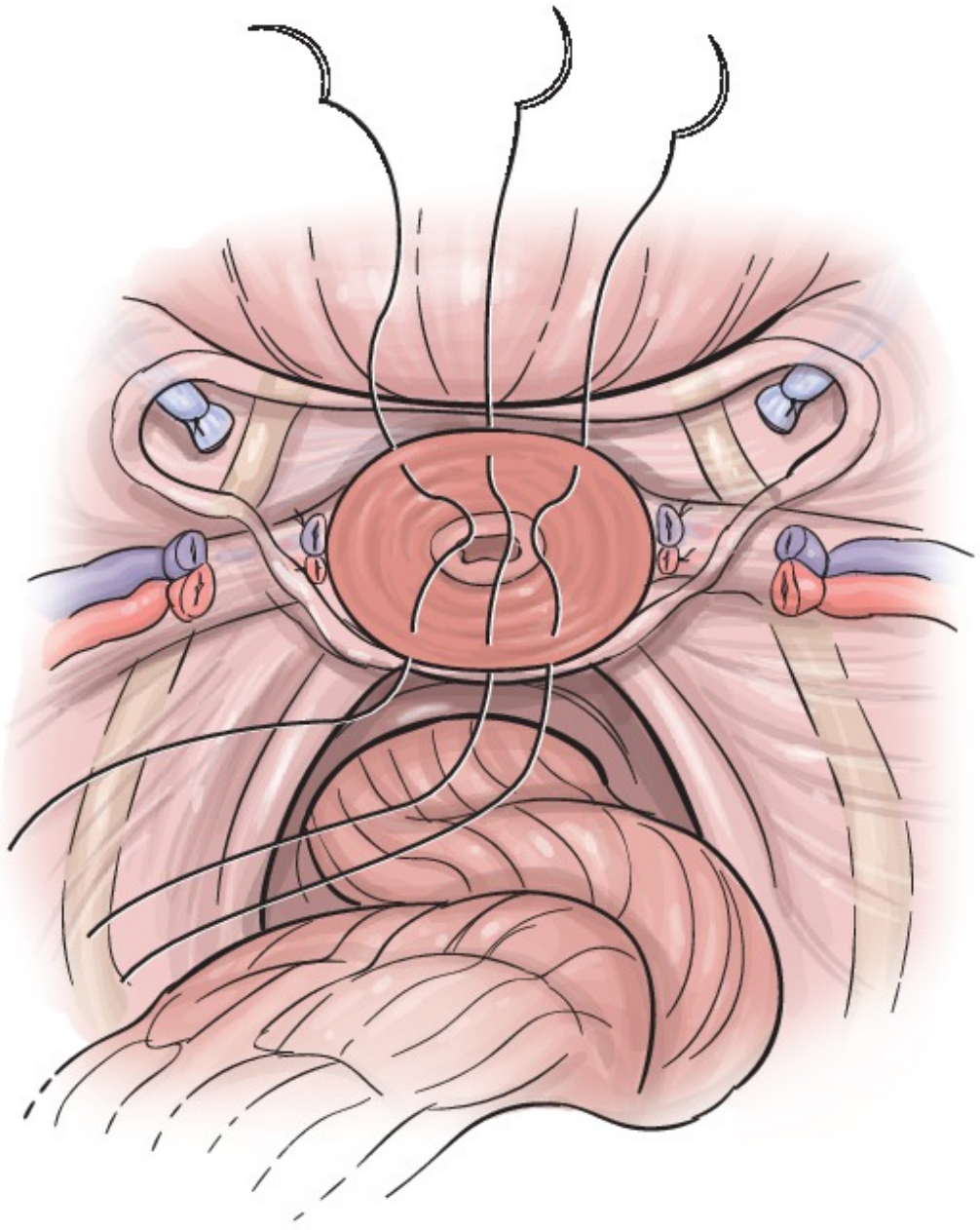

**FIGURE 23.14** The cervical stump is closed with delayed absorbable suture.

After the cuff (or cervical stump) is closed, the pelvis is copiously irrigated, and each pedicle is examined for hemostasis. Bleeding from capillaries or small-caliber vessels can be controlled with electrocautery or small-gauge suture. A right-angle clamp is particularly useful for achieving hemostasis on peritoneal surfaces

(by creating pedicles from straight edges). The course of the ureters should be followed and the relationship to sutures assessed. Evaluation of ureteral patency is imperative if ureteral dilation, kinking, or entrapment is suspected. Once hemostasis is assured, the tagged sutures are cut, and the self-retaining retractor and laparotomy packs are removed. The omentum is draped over the bowel toward the cul-de-sac, and the abdomen is closed (**BOX 23.6**).

## BOX 23.6 ADDITIONAL TIPS

### Supracervical Hysterectomy

- For supracervical hysterectomy or to amputate the fundus, place a wide malleable in the cul-de-sac to protect the sigmoid and retract the fundus firmly toward the ceiling.
- Amputating the cervix: Using cautery, heavy scissors, or a long-handled knife, begin the incision a few centimeters above the uterine vascular pedicles or remaining Heaney clamps. Cut straight across the cervix, being careful not to angle downward toward the vascular pedicles.

# SPECIAL SITUATIONS

## Supracervical (Subtotal) vs Complete (Total) Hysterectomy

Rates of supracervical hysterectomy in the United States increased from 0.7% to 7.5% between 1995 and 2004. A 2012 systematic review found no evidence linking cervical retention and improvement in sexual, bowel, or bladder function. When compared to complete hysterectomy, supracervical hysterectomy was associated with statistically but not clinically significant reductions in operating time (11 minutes) and estimated blood loss (57 mL). Immediate postoperative fever and urinary retention were less common in

patients after supracervical hysterectomy. However, persistent cyclic vaginal bleeding is reportedly 16 times more common after supracervical vs total hysterectomy. Historical arguments in favor of supracervical hysterectomy included improved sexual function, fewer postoperative complications, and theoretic prevention of pelvic organ prolapse as compared to complete hysterectomy, but evidence from randomized trials does not support these claims. Urogenital fistula is less likely to develop after supracervical compared to total hysterectomy. After supracervical hysterectomy, 1%-2% of patients undergo trachelectomy, most commonly for cervical prolapse. Benefits of supracervical hysterectomy appear to be limited to the intraoperative and immediate postoperative period. Citing limited benefits, and in light of the risks of cervical cancer (0.05%-0.27%) and future surgery for cervical bleeding, the French College of Gynecologists and Obstetricians 2021 Clinical Practice guideline recommends cervical removal in all patients undergoing hysterectomy for benign disease.

Women requesting supracervical hysterectomy should understand the need for continued cervical cancer screening and the potential impact of persistent endometrial tissue on the choice of hormone therapy. Significant bleeding during abdominal hysterectomy or other clinical need for rapid hysterectomy, such as obstetric hemorrhage, is an indication for a supracervical approach. Supracervical hysterectomy may also be considered if pelvic adhesions are such that, in the opinion of the experienced surgeon, the risk of adjacent organ injury associated with total hysterectomy outweighs the benefits. Premalignant or malignant disease of the reproductive tract is a contraindication to supracervical hysterectomy.

# Appendectomy

The risks of routine or coincidental appendectomy are generally greater than the benefits. Therefore, appendectomy at the time of abdominal hysterectomy should be reserved for patients with clinical indications.

## Culdoplasty

Vault suspension procedures at the time of hysterectomy are recommended when patients have concurrent symptomatic prolapse. However, recommendations for and against prophylactic culdoplasty at the time of abdominal hysterectomy are less straightforward and are largely based on expert opinion.

## Abdominoplasty

Some patients request cosmetic procedures at the time of gynecologic surgery, although exact frequency of simultaneous abdominoplasty and abdominal hysterectomy is unknown. Review of the American College of Surgeons NSQIP data suggests that the incidence of these concurrent procedures is about 1% of patients undergoing hysterectomy. A single episode of general anesthesia and surgical recuperation as well as decreased cost are frequently cited advantages of performing these procedures at the same time. Women undergoing major gynecologic abdominal procedures and abdominoplasty prior to the adoption of universal venous thromboembolism (VTE) prophylaxis experienced increased rates of blood transfusion and pulmonary embolus as compared to patients undergoing either procedure separately. However, in a more recent retrospective study, the rates of pulmonary embolism, surgical site infection, and major postoperative complications were not elevated after combined abdominoplasty and gynecologic surgery. Both total operating room time and hospital length of stay are reduced when these procedures are completed during the same surgical episode.

# THE CHALLENGING HYSTERECTOMY

## Obliteration of the Cul-de-Sac

Dense adhesion between the posterior cervical peritoneum and the anterior sigmoid or rectum obliterates the cul-de-sac and distorts normal anatomic landmarks. Scarring because of severe endometriosis or prior pelvic infection may prevent easy access to

the posterior cervix and uterosacral ligaments, as required for complete hysterectomy. Endometriosis over the uterosacral ligaments draws ureters medially from puckering and retraction of the ligaments and overlying peritoneum.

In such cases, to avoid serious injury to the rectosigmoid, the surgeon should use sharp dissection to separate the posterior peritoneum from the cervix and vagina to free ample space to proceed with trachelectomy. The hysterectomy can be completed after the ureters have been identified and the cervicovaginal peritoneum mobilized. The technique of “bottom-up” hysterectomy facilitates cervix and corpus removal when entry into the posterior cul-de-sac is not possible. To perform this procedure, the bladder is advanced anteriorly below the level of the external os and the vagina entered with a knife. The hysterectomy then proceeds backward by dividing cardinal ligaments starting from the ectocervix in the direction of the cervicouterine junction.

## Cervical and Lower Uterine Segment Fibroid

Debulking myomectomy provides space and exposure in some cases when large fibroids are present, but the need for intraoperative myomectomy is dependent on the location of the fibroid (rather than its size). Large cervical fibroids tend to displace ureters laterally and toward the uterine fundus. The average distance between the ureter and lateral cervix on CT imaging is slightly >2 cm in patients with normal anatomy but is within 5 mm in up to 10% of patients with cervical masses. If the size and location of the mass allows, retroperitoneal dissection and development of the pararectal and paravesical spaces facilitates safe separation of the adjacent rectum, bladder, and ureters. Depending on the bulk and lateral extent of the mass, a retroperitoneal approach may be a best first step, especially when distortion by the mass prevents a clear view of the uterine vessels. Once entered, if space allows, separation of the relatively avascular areolar tissue toward the pelvis may expose the uterine artery as it crosses over the ureter. This step is easier

laparoscopically because the laparoscope can be advanced behind large masses, but if clearly visualized, a suture ligature passed around the artery, or a large hemoclip reduces uterine perfusion. Isolation and division of the uterine artery and vein as they stretch over the lateral cervical mass is sometimes possible when the mass fills the pelvis. Surgeons frequently proceed with cervical myomectomy to improve visualization and identification of pelvic structures. As the myomectomy proceeds, ureters lying on the myoma surface fall laterally, but once the fibroid is removed, the remaining stretched and attenuated tissues do not always resemble normal anatomy. As in all cases, the uterine vessels on the side that are most accessible should be clamped and divided first. When the cause of wide cervical ballooning is an intracavitary fibroid, entry into the anterior endometrial cavity may permit delivery of the myoma through the fundus and can improve exposure for the completion of the hysterectomy.

By stretching and tenting the anterior peritoneum, cervical and anterior lower uterine fibroids frequently autodissect a clear plane for peritoneal dissection and bladder mobilization. After division of the utero-ovarian or IP ligaments, traction on the fibroid anterolaterally with a towel clip may provide adequate exposure of the vessels and ureter for placement of a hemoclip and temporary control of the uterine artery during myomectomy. Fibroids distorting the lateral anatomy of the cervix or lower uterus pose challenges with clamp placement, and myomectomy may restore familiar anatomic relationships. An incision on the superior-most aspect of the fibroid reveals the fibroid capsule. Dissecting within the capsule to separate the fibroid reduces the risk of injury to ureters and uterine vessels. Identification of the cervicovaginal junction in patients with cervical masses can be problematic. Finding the apex of the true vagina is facilitated when an assistant introduces a finger into the fornix, which can be palpated by the surgeon.

Fibroids or masses arising in broad and uterosacral ligaments also disrupt the normal anatomic course of the ureter. Broad ligament masses tend to displace the ureters medially, but the anatomic location of pelvic masses does not completely predict ureteral position. Therefore, to reduce the risk of injury, ureters

should be traced through their pelvic course prior to excising a cervical, broad ligament or uterosacral mass. Once identified, isolating the ureter with a vessel loop facilitates continual reassessment of its anatomic relationships to pelvic pathology.

# POSTOPERATIVE CARE

Current evidence no longer supports the tradition of withholding oral intake after hysterectomy in the immediate postoperative period regardless of the route. Previous concerns about the association of early feeding with vomiting, wound dehiscence, ileus, and bowel obstruction are unfounded. Compared to delayed feeding, patients initiating oral intake within 24 hours after major gynecologic surgery experience faster return of normal bowel function and improved patient satisfaction and surgical site infection rates.

In the absence of urinary tract injury, the indwelling catheter should be discontinued no later than the morning after surgery.

Pneumatic compression devices are not required once the patient is ambulating, which is encouraged on the afternoon, or evening on the day of surgery.

Typical recommendations for resumption of normal activities after abdominal hysterectomy are variable and largely based on theoretic concerns for incisional dehiscence. In the absence of scientifically based guidelines, most practitioners in the United States advise patients to return to work 6 weeks after uncomplicated abdominal hysterectomy. Workplace guidelines published by the medical disability advisor (http://www.mdguidelines.com/hysterectomy) agree with restrictions of prolonged standing and strenuous physical activity for 6-12 weeks after hysterectomy. This was also the conclusion of a group of expert Dutch gynecologists, general practitioners, and occupational therapists participating in a modified Delphi study designed to determine optimal guidelines for post-op care. The participants reached consensus and decided that lifting 5 kg and 30 minutes of sustained walking are appropriate at 2 weeks, and lifting 10 kg and activities such as bicycle riding are appropriate 3-4 weeks after abdominal hysterectomy. These professionals also agreed that carrying 15 kg, walking during an entire day, and working

for 8 hours a day are appropriate 6 weeks after uncomplicated abdominal hysterectomy. However, expert advice may not be generalizable to all patients, and the use of patient-reported data could optimize post-op guidelines. Expert-generated convalescence recommendations were provided to 337 healthy Dutch women after abdominal hysterectomy who also created and logged their own recovery plan. Patients reported time to resumption of 10 activities, and researchers considered the expert-based recommendations correct when 25% of the cohort resumed the activity within the recommended time. For abdominal hysterectomy, the expert recommendations were correct for all activities with the exception of driving, and return to work (68 days), which exceeded recommendations. Patients may resume sexual activity once the cuff has healed and is nontender on examination. Most surgeons recommend waiting 6 weeks prior to resumption of sexual activity. Postoperative care is reviewed in detail in Chapter 11.

Traditional patient follow-up occurs at 6 weeks after hysterectomy. Individual patient clinical and social factors should determine the optimal time for postoperative evaluation.

# REDUCTION OF PERIOPERATIVE RISK

Various procedures and interventions have been advanced as measures to reduce hysterectomy-associated perioperative risk. Serious risks of hysterectomy are rare, which leads some researchers to evaluate end point surrogates for safety that may or may not correlate with true improvement in outcomes. Pertaining to abdominal hysterectomy, some practices have been subject to reasonable scientific scrutiny, some are extrapolated from study of similar procedures, and others are passed from generation to generation of pelvic surgeons based on provider comfort and experience. When rigorous studies are lacking, the clinician should weigh the benefits, risks, and costs of these practices in the context of each patient.

# Ureteral Stents

Evidence does not support the use of routine prophylactic ureteral stents prior to abdominal hysterectomy for benign disease. In a randomized controlled trial of over 3000 patients undergoing major gynecologic surgery, no significant difference in the rate of ureteral injury occurred among catheterized and noncatheterized groups. However, based on individual circumstances, surgeons may opt to place stents for selected patients to facilitate ureteral palpation.

# Universal Cystoscopy

Early recognition and repair of urogenital injury decreases the risk of morbidity and reoperation. Retrograde bladder distention may be useful for the evaluation of suspected bladder injury, but this approach is not adequate for evaluation of the upper urinary tract. Cystoscopy at the time of hysterectomy provides information about bladder integrity and ureteral patency.

A retrospective study compared the intraoperative detection rates of urologic injury in patients prior to and after the institution of universal cystoscopy protocols. An increased use of intraoperative cystoscopy from 36% to 86% was associated with significant reduction in delayed diagnosis (0.7%, 95% CI 0.3%-1.2% compared with 0.1%, 95% CI 0.0%-0.3%). Similarly, in a systematic review of 79 studies of cystoscopy and benign gynecology, the intraoperative detection rate of ureteral and bladder injury was greater among patients managed with universal cystoscopy (95% for both) compared to selective use (18% ureter, 70% bladder). Conversely, in a retrospective review of NSQIP hysterectomy data between 2015 and 2017, there was no difference in the rate of delayed genitourinary injury among patients with or without intraoperative cystoscopy.

The American Association of Gynecologic Laparoscopists has issued guidelines for universal cystoscopy after laparoscopic hysterectomy, but professional society recommendations have not been published for cystoscopy with abdominal hysterectomy. There is no doubt that early detection of urinary tract injury reduces

morbidity, but the true clinical and economic impact of universal cystoscopy after abdominal hysterectomy is unclear. Surgeons should maintain a low threshold for cystoscopy or other evaluation of the bladder and ureters if there is concern for urinary tract injury.

Ureteral efflux may be evident when the ureter is partially ligated or kinked or in cases of incomplete transection. Thus, intraoperative intravenous pyelogram or urogram improves the detection of ureteral stricture and small defects and should be considered if there is a high suspicion for ureteral injury. Reassuring intraoperative cystoscopy findings should not prevent consideration of urinary tract injury in postoperative patients with postoperative ileus, abdominal distention, fever, persistent pain, or hematuria.

# Intraoperative Techniques to Reduce Blood Loss

Meticulous attention to proper surgical technique is typically adequate to achieve hemostasis during abdominal hysterectomy. However, cervical fibroids, larger uteri, abdominopelvic adhesion, and obesity may increase the risk of excessive bleeding during abdominal hysterectomy. Certain medications administered on the same day of the procedure may reduce intraoperative blood loss. A double-blind trial of 332 patients randomized to prophylactic tranexamic acid administration vs placebo at the start of hysterectomy found a significant reduction in subjective and quantitative blood loss, blood loss >500 mL, and reoperation secondary to hemorrhage in patients in the treatment group. The authors did not record the incidence of transfusion in either group.

In a systematic review, misoprostol administration immediately prior to abdominal hysterectomy for fibroids was associated with modest reductions in blood loss (−96.43 mL; 95% CI −153.52 to −39.34) and drop in hemoglobin level (0.59 g/dL; 95% CI 0.39-0.79). compared with placebo. Also, intraoperative injection of dilute vasopressin solution into the distal lower uterine segment, 1 cm medial to the uterine vessels, was associated with a significant reduction in estimated blood loss (mean difference 119.85 mL, $P <$

.001) but no difference in postoperative hemoglobin levels or transfusion rates.

Tissue-coagulating or vessel-sealing devices are additional options for hemostasis, but few studies have evaluated the use of these instruments during abdominal hysterectomy for benign disease. A network meta-analysis comparing hemostatic strategies during abdominal hysterectomy for benign, obstetric, and oncology indications concluded that LigaSure is a more effective hemostatic option when compared to misoprostol, pituitrin (bovine vasopressin and oxytocin), and tranexamic acid. The use of electrosurgery and other energy sources are reviewed in Chapter 7. The management of surgical hemorrhage is reviewed in detail in Chapter 39.

## Prevention of Adhesion

Inflammation caused by excessive tissue handling, desiccation, poor hemostasis, and ischemia are all potential antecedents to peritoneal adhesion. The development of postoperative adhesions is multifactorial, as meticulous surgical technique does not prevent acquired adhesion in all patients. Peritoneal closure does not reduce the development of adhesions. A Cochrane review found insufficient evidence to support or refute the use of adhesion prevention agents during gynecologic surgery for end points of pain, quality of life, adhesion at second look surgery, and future pregnancy.

# RISKS ASSOCIATED WITH ABDOMINAL HYSTERECTOMY

Risks associated with abdominal hysterectomy are summarized in **TABLE 23.1**. As noted, blood transfusion and surgical site infection are important considerations. Observational data from large-scale Scandinavian and European population studies cite a 3.57%-7.2% incidence of major surgical complications (excluding surgical site infection). Based on NSQIP data from 2008 to 2012, the incidence of all complications within 30 days of abdominal hysterectomy for benign disease in a large U.S. population was 7.9%. The American

College of Surgeons NSQIP calculator, available online at https://riskcalculator.facs.org/RiskCalculator/, approximates the probability of postoperative complications by procedure, based on individual patient characteristics (Chapter 2). This easy-to-use tool rapidly generates graphic comparison of patient and population risks for a variety of complications related to abdominal hysterectomy.

## TABLE 23.1
## Complications of Abdominal Hysterectomy

| COMPLICATION | INCIDENCE (%) |
|---|---|
| Blood transfusion | 4-6 |
| Bowel injury | 0.4-1 |
| Urinary tract injury<br>Ureteral<br>Bladder | 1.4-4.8<br>0.04-1.7<br>0.16-2.3 |
| Urogenital fistula | 0.3 |
| Urinary tract infection | 2-5 |
| Sepsis | 0.08 |
| Surgical site infection—superficial | 2.5-6 |
| Cuff cellulitis | 2 |
| VTE | 0.5-0.6 |
| Cuff dehiscence | 0.4 |
| Neuropathy | <2 |
| Death | 0.04-0.17 |

## Transfusion

In a retrospective analysis of NSQIP data from 2008 to 2012, the rate of blood transfusion was 5.7% among 12 284 patients during abdominal hysterectomy.

## Postoperative Infection

The true incidence of surgical site infection after abdominal hysterectomy is unclear because of different study methodologies and definitions. Data from large prospective studies and systematic reviews place the risk for all surgical site infection categories between 2.5% and 6% after hysterectomy. Cuff cellulitis complicates ~2% of cases regardless of the route of hysterectomy. Along with prolonged surgical time, the abdominal route is a consistent risk factor for the development of deep incisional space surgical site infection after hysterectomy.

Increased awareness, application of surgical site infection presurgical bundles, safety measures, and checklists have contributed to an apparent reduction in surgical site infection rates in the United States. Since operative time is a consistent risk factor for surgical site infection, patients with prior pelvic surgery, large cervical fibroid, or other conditions that may increase the duration of surgery can be reasonably counseled that their individual surgical site infection risk may be greater than that in patients without these conditions.

## Cuff Dehiscence

Dehiscence of the vaginal cuff is rare after abdominal hysterectomy as compared to laparoscopic hysterectomy, occurring in <0.4% of patients. Purported risk factors include infection and trauma during the post-op period. Intercourse is a common antecedent to cuff dehiscence.

## Urinary Tract Injury

The proximity of the uterus and its attachments to the bladder ureter and rectum increases the possibility of injury. The overall risk of damage to the urinary tract during all types of hysterectomy is 1%-4.8%. The abdominal route is associated with a lower risk of urinary injury as compared to laparoscopic hysterectomy (odds ratio, 2.41; 95% CI 1.24-4.82); the rate of urinary injury is similar for abdominal and vaginal hysterectomy. Data from large-scale observational studies indicate that bladder injury is more likely than ureteral at the time of hysterectomy. For example, of over 5000 participants in the FINHYST prospective study of hysterectomy complications, bladder trauma occurred in 1% and ureteral in 0.3%. Similarly, the incidence of bladder and ureteral injuries was 2.3% and 1.7%, respectively, in 529 patients after abdominal hysterectomy in a prospective study of universal cystoscopy after hysterectomy. Both prior cesarean delivery (odds ratio, 4.01; 95% CI 2.06-7.83) and uterine weight of >5000 g increase the odds of bladder injury (odds ratio, 2.88; 95% CI 1.05-7.90). Most bladder trauma involves the dome of the bladder, and 80% of ureteral injuries occur lateral to the cervix near the uterine artery.

Urinary tract injury at the time of hysterectomy may lead to urogenital fistula. The rate of urogenital fistula was 0.3% in a retrospective review of California hysterectomy data between 2005 and 2011. Immediate vs later recognition of urogenital injury was associated with a reduced risk of fistula formation after both bladder and ureteral injury.

## Gastrointestinal Injury

Gastrointestinal injury complicates 0.39%-0.7% of hysterectomies regardless of the route. Adhesions from prior surgical procedures, endometriosis, and infection all increase the risk of bowel injury. Bowel injury was significantly associated with adhesiolysis in the prospective FINHYST study (odds ratio, 29.07; 95% CI 7.17-117.88). Older age and an abdominal approach increase the odds of bowel injury.

## Complications Related to Adhesion

Patients scheduled for abdominal hysterectomy are at a greater risk for the development of adhesion than their laparoscopic hysterectomy counterparts, presumably related to the moist laparoscopic environment, reduced tissue manipulation, and blood loss. Acquired adhesions may cause future pain and adversely affect quality of life, but the most serious consequence of adhesion is bowel obstruction. Based on retrospective data, the rate of small bowel obstruction after >47 000 hysterectomies for benign disease was 5.9/1000 between 2014 and 2016. While the route of hysterectomy was not a risk factor for bowel obstruction, factors that are associated with abdominal hysterectomy (eg, non-White race, prior surgical history, long procedure time, and lysis of adhesions) were significantly associated with a greater odds of bowel obstruction.

## Postoperative Neuropathy

Postoperative neuropathy affects <2% of patients after gynecologic surgery. Compression, stretch, suture, surgical clips, clamps, and surgical energy devices may cause nerve ischemia, angulation, entrapment, trauma, and transection. Femoral neuropathy is the most common compression-related neuropathy associated with benign abdominal hysterectomy with an incidence between 0.8% and 11%. The use of self-retaining retractors with deep lateral blades increase the risk of ischemia by compressing the femoral vasa nervorum. Transection, angulation, and stretch during fascial closure of Pfannenstiel incisions are the likely culprits of ilioinguinal and iliohypogastric neuropathy, which have been observed in up to 4% of patients after abdominal hysterectomy.

## Regret Childbearing/Reproductive Options

Greater than 10% of premenopausal patients undergoing hysterectomy for benign disease desire another pregnancy. Evidence indicates that these patients experience greater anxiety,

depression, regret, and confusion during the first 2 years after surgery than do patients who voluntarily completed childbearing.

## Sexual Function

Among more than 1100 sexually active women in the Maryland Women's Health study, all parameters of sexual function improved after hysterectomy (including frequency of sexual relations, libido, and orgasm). Dyspareunia was reduced after surgery. Premenopausal women prospectively completing the Female Sexual Function Index had significantly improved scores 6 months after hysterectomy regardless of route. Improvement in pain and bleeding symptoms may account for the improvement in sexual function identified in this and other prospective studies. Sexual satisfaction prior to hysterectomy appears to be the most reliable predictor of post-op sexual function. However, predicting sexual health in patients after abdominal hysterectomy is difficult because of methodologic variation among studies and the complexity of sexual dysfunction.

## Incontinence

The effects of hysterectomy route on incontinence symptoms are difficult to discern. In the Maryland Women's Health study, 89.5% of 1299 participants completed a Urinary Symptom Scale prior to surgery and at 6-month intervals for 2 years. Incontinence symptoms improved in most women 2 years after hysterectomy, and this reduction was most notable in women with moderate or severe symptoms prior to surgery (61.2% and 86.5% reduction in symptoms, respectively). Symptom severity worsened in just 16.7% of women reporting no or mild, 9.6% moderate, and 3.2% severe symptoms prior to hysterectomy. In a 2017 ten-year longitudinal cohort study, hysterectomy was not associated with an increased prevalence of incontinence in 371 patients vs controls.

## Prolapse

The cumulative incidence of pelvic floor reconstructive surgery after hysterectomy is 5%-12%. In an analysis of over 150 000 Danish women, an indication of pelvic organ prolapse repair at the time of hysterectomy was the strongest predictor of additional future pelvic floor reconstructive surgery.

## Menopause

Biochemical markers or ovarian function and symptom questionnaires were evaluated in a prospective cohort of 406 patients undergoing premenopausal hysterectomy and compared to 465 controls who did not undergo hysterectomy. In this study, hysterectomy patients had nearly twice the risk of ovarian failure within 4 years as compared to controls (HR, 1.92; 95% CI 1.29-2.86).

## Effect on Metabolic Disorders and Cardiovascular Disease

Women followed for over 21 years after hysterectomy had significantly higher odds of developing hyperlipidemia, hypertension, obesity, cardiac arrhythmia, and coronary artery disease than did age-matched controls. These risks persisted even in patients with ovarian conservation.

## Mortality

Death after hysterectomy for benign disease is exceedingly rare. Between 2008 and 2012, the recorded all-cause death rate was 0.04% after abdominal hysterectomy performed for benign conditions. In their population-based analysis of data collected by the Nationwide Inpatient Sample of all patients who underwent an abdominal hysterectomy at 741 U.S. hospitals between 1998 and 2010, Wright et al. found an overall mortality rate of 0.17%.

## Readmission

Penn et al. reviewed 30-day NSQIP readmission data from 9869 patients after abdominal hysterectomy. Between 2012 and 2013, the 30-day hospital readmission rate after abdominal hysterectomy was 3.7%, and 82% of readmissions occurred within 2 weeks of the procedure. Surgical site infection was the most common diagnosis, constituting 37% of readmissions. Abdominal hysterectomy was associated with fewer readmissions for medical complications (including deep venous thrombosis) as compared to both laparoscopic hysterectomy and vaginal hysterectomy. Surgical injury as a cause for readmission is much less common after abdominal hysterectomy vs either laparoscopic hysterectomy (odds ratio, 2.3; 95% CI 1.48-3.65) or vaginal hysterectomy (odds ratio, 2.3; 95% CI 1.29-3.97).

# Learners and Hysterectomy

The effect of teaching and learners as surgeons on surgical outcomes is an important consideration. Few studies have evaluated the impact of residents and fellows on surgical outcome after hysterectomy.

By analyzing NSQIP surgical outcomes data from over 22 000 hysterectomies for benign disease between 2010 and 2012 (including 3765 abdominal hysterectomies without and 3038 abdominal hysterectomies with resident involvement), Barber et al. found no association between resident involvement and major complications including VTE, deep or organ space surgical site infection, fascial dehiscence, return to operating room, and death. However, a statistical increase in minor complications (urinary tract infection, blood transfusion, and superficial wound infection) occurred when residents were involved as surgeons during abdominal hysterectomy (odds ratio 1.61, 95% CI 1.38, 1.87), and persisted after adjusting for BMI, medical comorbidity, and surgical complexity (odds ratio, 1.56; 95% CI 1.33, 1.82). Operating time increased during all routes of hysterectomy when residents were involved, and the association with trainees and minor complications during abdominal hysterectomy persisted after adjusting for operative time (odds ratio, 1.34; 95% CI 1.13-1.57).

Studies such as these provide interesting insight into the effect of learner participation on surgical outcomes, although the retrospective design precludes determination of the true amount of resident participation. Furthermore, the findings of these studies, merely 10 years old, may no longer be applicable even today. As both residents and attending surgeons have become more adept at laparoscopic hysterectomy, associated with a national call to increase vaginal hysterectomy, only the most technically challenging cases require an open abdominal approach. Largely due to these trends, current residents in training perform about half the number of abdominal hysterectomies as compared to their counterparts a decade ago. The median number of abdominal hysterectomy per graduating residents functioning as primary surgeons (performed >50% of the procedure) has declined substantially from 85 in the academic year 2002-2003 to 27 in the academic year 2020-2021, or a decrease of 68.2%%. Accreditation Council of Graduate Medical Education reports of laparoscopic hysterectomy experience since 2008-2009 show an increase from 20 cases per graduating resident to 56 in 2020-2021, or an increase of 180% (**FIG. 23.15**). The principles of good surgical technique apply regardless of the route of hysterectomy, and the basic procedural steps of abdominal hysterectomy and laparoscopic hysterectomy are similar. For this reason, one may reason that learners completing multiple laparoscopic hysterectomies can adapt to open procedures. But in 2015, 60% of fellowship directors reported that only 46% of first-year fellows were capable of independently performing an abdominal hysterectomy. Competence with laparoscopic hysterectomy was 18% among reproductive endocrinology and infertility (REI) fellows but was unreported for fellows in other subspecialties. These results seem surprising since, with the exception of years impacted by the COVID-19 pandemic, the mean number of hysterectomies completed by graduating residents has remained relatively stable since 2002 (see **FIG. 23.15**). Diluted experience with each route of hysterectomy may explain the observed lack of proficiency, or each specific approach to hysterectomy may require a different skill set. Simulation training and the use of preoperative mental imagery improve surgical confidence; but an association between simulation

training for abdominal hysterectomy and patient outcomes has not been proven. In decades past, abdominal hysterectomy was a core procedure for postgraduate year 2 or 3 gynecology residents; however, the combination of diminishing experience and surgical complexity of patients undergoing abdominal hysterectomy may require a shift of this trend toward the later years of training.

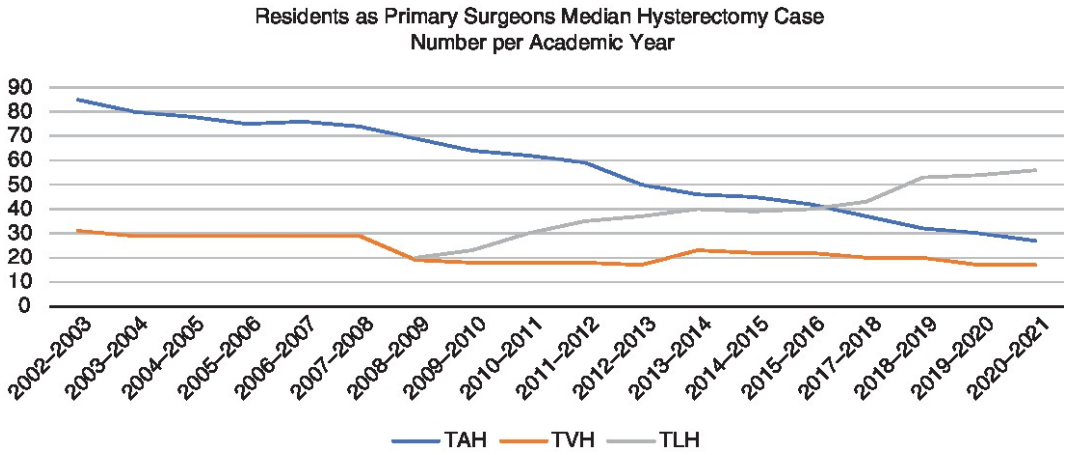


**FIGURE 23.15** ACGME data: residents as primary surgeon's median number hysterectomy by type per academic year. TAH, total abdominal hysterectomy; TVH, total vaginal hysterectomy; TLH, total laparoscopic hysterectomy. (Data from Accreditation Council for Graduate Medical Education (ACGME) web site. www.acgme.org. Accessed on September 22, 2021.)

# KEY POINTS

- Compared to vaginal and laparoscopic hysterectomy, abdominal hysterectomy is associated with longer hospital stay

and higher risk of surgical site infection. Thus, the abdominal route should be reserved for situations in which the experienced gynecologic surgeon considers the abdominal approach the safest option. Examples include when uterine or adnexal disease or adhesions create substantial anatomic distortion and when tissue morcellation is contraindicated.

- Black patients are more likely to have abdominal over minimally invasive hysterectomy, and more perioperative complications than White patients. This disparity should be considered when planning hysterectomy route, and efforts made to provide minimally invasive options to all appropriate candidates.
- Subtotal (supracervical) hysterectomy is not associated with improved sexual, bladder, or bowel function as compared to total (complete) hysterectomy.
- Prior to abdominal hysterectomy, medical pretreatment of fibroid-associated anemia with depot leuprolide acetate is associated with improved preoperative hemoglobin concentration, reduced intraoperative blood loss, and transfusion.
- The patient may be positioned supine or in low lithotomy for abdominal hysterectomy. The right-handed primary surgeon should stand on the patient's left.
- Sharp dissection is recommended for mobilizing the bladder off the cervix and proximal vagina.
- After the uterine vascular pedicles are clamped and secured, safe amputation of the uterine fundus is possible. With an enlarged fundus that obscures the surgical field, this may be an intermediate step that improves visualization during the process of total hysterectomy. The cervix can be removed separately in such cases.
- After removal of the cervix, the closure of the vaginal cuff must include the full thickness of vaginal mucosa to prevent bleeding, cuff hematoma, and vaginal granulation.
- Hysterectomy in the setting of cervical or broad ligament masses, such as leiomyomata, may be particularly challenging.

Retroperitoneal dissection, with development of the pararectal and paravesical spaces, is required in such cases. The ureters should be traced through their pelvic course prior to excising a cervical or broad ligament mass.

- Surgical site infection continues to be the most common indication for readmission after abdominal hysterectomy.
- The urinary tract is the most common site of adjacent organ injury during abdominal hysterectomy. Bladder injury occurs more frequently than does ureteral and is most often seen at the dome of the bladder. Ureteral injury is most often encountered lateral to the uterine vessels.

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# CHAPTER 24

# MINIMALLY INVASIVE HYSTERECTOMY- LAPAROSCOPIC AND ROBOTIC-ASSISTED HYSTERECTOMY

Ted L. Anderson and Ronald D. Alvarez

**History of Minimally Invasive Surgery**
Total Laparoscopic Hysterectomy
Laparoscopic Supracervical Hysterectomy
Robotic-Assisted Laparoscopic Hysterectomy
**Advantages of Minimally Invasive Approach**
Total Laparoscopic Hysterectomy
Laparoscopic Supracervical Hysterectomy
Robotic-Assisted Laparoscopic Hysterectomy
**Operative Preparation**
Patient Selection and Preparation
Patient Positioning
Robotic Equipment Setup
Port Placement for Conventional Laparoscopy
Port Placement for Robotic-Assisted Laparoscopy
Uterine Manipulation

**Operative Technique**
The Adnexa
The Uterine Corpus and Vessels
Colpotomy
Uterine Extraction
Morcellation
Cuff Closure
**Complications**
Cuff Dehiscence
Wound Complications
Urologic Injury
**Conclusion**

# HISTORY OF MINIMALLY INVASIVE SURGERY

Hysterectomy is the most common gynecologic procedure performed worldwide. Historically, the majority of have been performed through a laparotomy incision. A laparoscopic approach to hysterectomy was first described in 1989. In 2005, the FDA approved the da Vinci Surgical System (robotic-assisted laparoscopy) for gynecologic procedures. By 2010, 40% of hysterectomies for benign indications were performed laparoscopically, and there was increasing adoption of this approach for selected gynecologic cancers. Professional societies like the American College of Obstetricians and Gynecologists (ACOG) and the American Association of Gynecologic Laparoscopists (AAGL) encourage the use of a minimally invasive approach to hysterectomy, including the vaginal hysterectomy. In 2020, most hysterectomies were performed laparoscopically.

The term “minimally invasive hysterectomy” refers to a family of procedures that vary in the degree to which the procedure is performed laparoscopically. This includes a range of procedures including a vaginal approach with no laparoscopic component total vaginal hysterectomy, (TVH), a laparoscopic-assisted vaginal hysterectomy (LAVH), where ovaries are released laparoscopically and hysterectomy is completed vaginally, and completion of the entire procedure laparoscopically, including cuff closure called total laparoscopic hysterectomy (TLH). The application of robotic technology to laparoscopic surgery brings the advantages of a three-dimensional high-definition camera system and gear-driven instruments, permitting an almost unlimited range of motion mimicking that of the human wrist. Robotic-assisted total laparoscopic hysterectomy (RA-TLH) has stimulated the adoption of a minimally invasive approach to hysterectomy by many gynecologists because of clearer identification of tissue planes and more facile laparoscopic suturing using the robotic platform.

In this chapter, we will discuss TLH, laparoscopic subtotal (supracervical) hysterectomy (LSH), and RA-TLH. LAVH is a variant of the vaginal hysterectomy that employs the laparoscopic approach simply to mobilize adnexal structures and treat relevant abdominopelvic pathology such as adhesions. Principles relevant to this procedure are discussed in the vaginal hysterectomy section.

# Total Laparoscopic Hysterectomy

Laparoscopy was incorporated into gynecologic practice in the 1950s by Raoul Palmer in France, followed by Kurt Semm in Germany. It was not until 1989 that the landmark description of the first laparoscopic hysterectomy was published by Harry Reich and John DeCaprio. Viewing it as a substitute for abdominal hysterectomy (AH) and not for vaginal hysterectomy, they noted that this approach “may avoid the increased morbidity associated with abdominal surgery while retaining the surgical advantages of the abdominal approach, that is, thorough visualization and easy access to the vascular pedicles.”

## Laparoscopic Supracervical Hysterectomy

Supracervical hysterectomy was first performed by Wilhelm Alexander Freund in 1878 and remained the leading technique of hysterectomy for over 80 years. At that time, removal of the cervix was associated with complications such as peritonitis, fistula, hemorrhage, ureteral injury, cystotomy, and enterotomy. In fact, the mortality rate associated with total hysterectomy through the 1930s was 50% higher compared with the supracervical hysterectomy. By the late 1940s, supracervical hysterectomy was abandoned in favor of total hysterectomy. This trend reflected the considerable refinement of surgical instruments and techniques, introduction of safer and more effective antibiotics, improvement of blood banking technology with transfusions becoming more routine, and the unfortunate recognition of development of cervical cancer in almost 2% of patients with residual cervices.

## Robotic-Assisted Laparoscopic Hysterectomy

The robotic surgical platform was developed as a military tool for field surgery. With this platform, the surgeon sits at a console remote from the patient and controls instruments that translate directly into fine operative movements with the assistance of three-dimensional, high-definition video for visualization. The da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) was FDA approved in 2000 for general laparoscopic procedures and in 2005 specific approval was granted for gynecologic procedures. In 2021, the da Vinci Surgical System advanced to its 4th generation system and is used in 67 countries to perform ~8.5 million cases. The robotic surgical platform has stimulated a minimally invasive approach to hysterectomy around the world. However, disparities exist in the availability of the robotic platform for the performance of hysterectomy for benign indications. Specifically, women were less

likely to undergo robotic hysterectomy if they lived in rural areas, were African American, or were publicly insured or uninsured.

# ADVANTAGES OF MINIMALLY INVASIVE APPROACH

The decision for appropriateness of hysterectomy as a therapeutic intervention is the same regardless of whether a laparoscopic approach is being considered. However, the specific method of access for hysterectomy is generally a function of patient pathology and surgeon skill and preference. Nonetheless, there are unique characteristics that distinguish TLH, LSH, and RA-TLH.

## Total Laparoscopic Hysterectomy

A Cochrane database systematic review of over 3600 patients in 27 randomized studies pointed to significant advantages of laparoscopic hysterectomy (TLH) over AH, including less blood loss, fewer wound infections or and fevers, smaller incisions and less pain, shorter hospital stay, and speedier recovery. However, TLH was associated with longer operating time and greater likelihood of urinary tract injuries. The eVALuate trial is one of the largest randomized trials comparing different approaches to hysterectomy. Conclusions indicated that TLH was associated with less pain, quicker recovery, and better quality of life compared with AH. The report also concluded that TVH was the preferred approach as it offered similar benefits as TLH with less cost and shorter operating times.

While TVH may be the preferred hysterectomy route for a variety of reasons, there are patients for whom this approach is less than ideal. Specifically, a laparoscopic approach may be favored in patients who are morbidly obese, who have constricted pelvic anatomy, who have no uterine descensus, or who have known or suspected concomitant pelvic disease such as adhesions or endometriosis. There are few contraindications to laparoscopic hysterectomy, and most are relative contraindications related to the patient's comorbidities, including deficiencies in main physiologic

functions and elevated body mass index. Contraindications include the following:

- Medical conditions that limit the ability to create a pneumoperitoneum, adequate ventilation, or Trendelenburg positioning (eg, morbid obesity, increased intracranial pressure, presence of ventriculoperitoneal shunt, portal or pulmonary hypertension)
- Severe abdominal or pelvic adhesive disease or other conditions that preclude safe entry or adequate operating space (eg, advanced pregnancy, bulky uterine or fibroid size that precludes prevents access to uterine vessels)

There are recognizable challenges to performing laparoscopic hysterectomy, including the following:

- Reduced range of motion through laparoscopic ports with conventional laparoscopic instruments
- Reduced field of view in which only the tissues actively being manipulated can be viewed by the surgeon
- Reduced depth perception: a 3D surgical field is converted to a 2D video image
- Reduced haptics and difficulty in assessing degree of force needed or being applied to tissues
- Reduced intuitive movements due to the fulcrum effect in which the tool tips move in the opposite direction as the surgeon's hands

In all cases, a decision regarding route of hysterectomies is largely dependent on the surgeon's capabilities.

## Laparoscopic Supracervical Hysterectomy

In the early 1990s, after descriptions of successful laparoscopic techniques for supracervical hysterectomy by Kurt Semm and Thomas Lyons, there was a resurgence of interest in the

supracervical hysterectomy. Some have suggested that this was driven equally by surgeon interest in that a laparoscopic hysterectomy was easier, quicker, and safer to perform than TLH as well as refinement of instruments and devices to facilitate advanced laparoscopic procedures and tissue extraction. Conventional wisdom would assume that preservation of the cervix during LSH reduces the potential for intraoperative injury to the ureter, bladder, and rectum that would more likely occur during the transection of the cardinal ligament complex required to isolate and remove the cervix. Furthermore, hemorrhage most often occurs below the level of the uterine isthmus. Despite numerous studies comparing laparoscopic, vaginal, and abdominal approaches to hysterectomy, comparatively few studies have focused on the role of the cervix. A systematic review of 40 studies published in 2014 reported the rate of urinary tract injury in TLH to be ~0.84%, which fell to under 0.23% with LSH. Accordingly, there is objective evidence that leaving the cervix does indeed offer protection from complications in selected patients.

Another driver of LSH has been patient perception that pelvic support and sexual satisfaction would be preserved or enhanced when compared to TLH. However, a systematic review of randomized trials comparing LSH with TLH documented no differences in rates of incontinence, prolapse, dyspareunia, sexual satisfaction, transfusion rate, recovery times, and readmission rates. Interestingly, a 2-year prospective study demonstrated significant overall improvement in sexual functioning, including increased libido, coital activity, and orgasm with decreased dyspareunia after TLH. Although several other studies have suggested increased orgasmic frequency after LSH, subsequent studies have failed to confirm these findings. Nonetheless, perception is a powerful motivating force. Many women contemplating elective hysterectomy consider preservation of the cervix a pivotal factor in the decision whether to undergo this procedure.

During the past decade, many gynecologists have reassessed the value of supracervical hysterectomy. The rationale for routine removal of the cervix to prevent cervical cancer has been largely eliminated by the effectiveness of present-day precancer screening and improvement in treatment for preinvasive disease. Development

of cervical dysplasia is rare in appropriately selected low-risk patients, and there is no evidence that supracervical hysterectomy increases the risk of cervical cancer. Removal of the uterine corpus alone is adequate treatment for women suffering from abnormal uterine bleeding or benign uterine fibroids.

Nonetheless, many surgeons remain reluctant to offer this approach to women requiring hysterectomy for benign disease, citing the risk for persistent pain and cyclic vaginal bleeding due to retained endometrial tissue at the cervicouterine junction necessitating subsequent trachelectomy. The incidence of persistent cyclic bleeding or spotting remains low (between 2% and 12%) and is more common in younger patients and those with preexisting endometriosis. In fact, some have considered the presence of extensive endometriosis to be a relative contraindication for LSH as these women may have persistence of dyspareunia if the cervix is retained. The only absolute contraindication to supracervical hysterectomy is the presence of a malignant or premalignant condition of the uterine corpus or cervix. Supracervical hysterectomy is indicated for select patients who choose this procedure after appropriate counseling, and occasionally in surgical emergencies. Supracervical hysterectomy should not be performed simply because of the surgeon's lack of comfort with removing the cervix. In these situations, assistance from more skilled surgeons should be sought.

## Robotic-Assisted Laparoscopic Hysterectomy

Similar to conventional laparoscopy, the robotic approach results in lower estimated blood loss, shorter length of stay, improved quality of life in the postoperative period, and fewer complications when compared with the abdominal approach. Several randomized controlled trials and a 2016 meta-analysis by Albright et al. have shown that robotic-assisted hysterectomy is safe and feasible but provided no specific improvement in patient outcomes over that achieved with conventional laparoscopic hysterectomy and in most

instances was associated with a longer operative time. However, advantages of the robotic platform over conventional laparoscopy include improved surgeon ergonomics, visualization, elimination of tremor, instrument range of motion, and a rapid learning curve. The enhanced operational advantages of the robotic platform offer the opportunity to avoid an abdominal approach in select obese patients and in patients who require other simultaneous procedures at the time of hysterectomy (eg, staging, lysis of adhesions, etc.)

Historically, little attention has been directed toward the impact of surgical procedures on the surgeon. The design of the robotic surgical console has been demonstrated to result in less back and neck strain and less overall fatigue. This benefit is amplified by three-dimensional high-definition visualization, which provides improved depth perception as well as better delineation of spatial relationships between pelvic structures and tissue planes compared with the two-dimensional view of traditional laparoscopy.

Robotic instruments are also geared to provide an almost unlimited range of motion. The ratio between distance of hand movement at the console and instrument movement at the operative site can be scaled depending on the specific needs of the procedure. This relationship also impacts the sensitivity of motion, which can virtually eliminate the impact of any hand tremor the surgeon may have.

There are some distinct disadvantages of the robotic platform, including the lack of haptic feedback, difficulty accessing the upper abdomen, and lack of direct access to the patient. Further, the cost-effectiveness of robotic vs other hysterectomy approaches has been a subject of intense scrutiny. While there is clearly improved cost-effectiveness of robotic hysterectomy compared with AH, multiple reports published within the first decade after FDA approval of robotic surgery demonstrated that costs are higher for robotic hysterectomy compared with laparoscopic hysterectomy performed for both benign and cancer indications. However, more recent studies have shown that the cost of robotic hysterectomy is more comparable to laparoscopic hysterectomy with several factors that can mitigate the initial investment in the platform to make robotic surgery more cost-effective.

# OPERATIVE PREPARATION

## Patient Selection and Preparation

The principles of patient evaluation, selection, and optimization prior to hysterectomy are identical regardless of whether the planned procedure is TLH, LSH, or RA-TLH. The patient must first be considered an appropriate surgical candidate, an appropriate candidate for hysterectomy, and then an appropriate candidate for laparoscopy. Prior to any elective surgical intervention, medical comorbidities should be evaluated and medical comorbidities optimized when conditions such as diabetes, hypertension, and pulmonary compromise are present. Special attention should be made to coordinate care with the anesthesia team with respect to the impact that abdominal insufflation and prolonged Trendelenburg positioning can have on critical cardiopulmonary physiology, including peak inspiratory pressures and cardiac preload.

A critical aspect of patient preparation is the informed consent. This should include a discussion of risks that will be incurred by the patient and a discussion of the inability to complete the procedure with robotic assistance or conventional laparoscopy for a variety of reasons (eg, poor tolerance of positioning or equipment malfunction) resulting in the potential need for conversion to a laparotomy. The informed consent process is an educational process that should inform the patient, in terms she can understand, and reviews all the relevant information a reasonable patient would want to know to make decisions related to the planned procedure.

## Patient Positioning

The patient should be positioned in the low lithotomy position providing access to the perineum for uterine manipulation and tissue removal. The patient should be situated sufficiently far down on the table. We find this critical concept to be often underestimated only to encounter challenges maneuvering the uterus when the table interferes with range of motion of the uterine manipulator after the procedure is well under way. One useful trick that can help address

this is to rock the patient's hips forward to reduce lordosis, which can stabilize the patient's pelvis. It is imperative that arm and leg position and padding relieve pressure points that could lead to nerve injury. A draw sheet placed across the operating table wrapped under well-padded arms and tucked back under the patient's back can provide excellent arm stability, maintain good function of IVs and blood pressure cuff, and allow for maximum mobility of the surgeon throughout the procedure.

There are no specific variants from the basic principles of patient positioning unique to RA-TLH; however, special attention should be paid to ensure that the patient does not slip on the table when placed in steep Trendelenburg positioning, as this becomes quite problematic after the docking robotic arms. It is essential that the patient is placed directly on a foam pad that is taped to the operating table to prevent slipping or another pad designed to prevent slippage. Alternatively, a gel pad or a surgical beanbag can be used to stabilize even larger patients. Although shoulder braces are discouraged due to the increased potential for brachial plexus injury, placing them laterally over the acromioclavicular joint rather than medially on the shoulder may minimize that risk. A foam pad and straps are placed securely but not too restrictively across the patient's chest and secured to the bed with tape or Velcro straps to further prevent slipping. Once positioned and before performing surgical scrub, the patient should be placed in maximum Trendelenburg position to confirm adequate positioning and stability prior to starting the surgical procedure ("tilt test"). This also allows the anesthesiologist to assess the patient's pulmonary status in steep Trendelenburg position. She is then returned to a level position.

# Robotic Equipment Setup

The robotic platform consists of the surgeon console, the patient-side cart with robotic arms, the control tower with the vision system, and the instruments. The surgeon should review the equipment with the operating room staff prior to induction of anesthesia to confirm that everything necessary is present. The surgeon console is located

outside of the sterile field, generally several feet from the patient. The patient-side cart, positioned next to the patient, consists of three or four arms (depending on the robot model) that dock to the robotic ports, hold the instruments, and respond to commands from the surgeon's hands at the console. The robotic arms should be draped prior to patient entry into the room, and the console should be prepared with surgeon-specific settings for height and comfort. One or more large screens are positioned to provide the surgical team members a two-dimensional view of the operative field. Some robotic models have a teaching adaptation that allows on-screen drawing and/or secondary control where command of the surgical instruments can be recovered immediately from one surgeon to another if needed to provide guidance or prevent injury.

## Port Placement for Conventional Laparoscopy

There are several variables that must be considered when selecting specific port placement sites. However, the camera port is almost always placed in the midline with access ports for operative instruments placed laterally. For TLH and LSH procedures when the uterus is relatively small (14 week or less), the camera port is generally placed in the midline at the level of the umbilicus. This can be placed using a traditional closed technique before or after abdominal insufflation, with or without an optical trocar to visualize penetration through abdominal wall layers. Alternatively, an open (Hasson) technique or a left upper quadrant (Palmer point) entry might be chosen; the Hasson method has been associated with decreased incidence of vascular injury. While these alternative modes of initial entry are often recommended in patients with prior surgery where periumbilical adhesions are suspected, there is no evidence that any specific entry technique always prevents injury to underlying viscera. There is strong evidence to support using the surgeon's most preferred entry method regardless of the underlying pathology.

All subsequent accessory ports should be placed under laparoscopic guidance. The primary lower lateral ports should be placed lateral to the rectus sheath to avoid the inferior epigastric vessels and just far enough cranial to the anterior superior iliac spines to allow an adequate angle to approach the deep pelvis. Optimal positioning should provide a good angle for access to ipsilateral pelvic structures and to provide retraction for access to the contralateral pelvic structures. Caution should be taken not to place these ports too low on the abdominal wall close to the pelvic bones. Such a choice of port placement, which is often driven by concern for cosmesis rather than functionality, usually results in an insufficient angle to access to the ipsilateral deep pelvic structures and increases the chance of injury to the ilioinguinal, iliohypogastric, and superficial circumflex vessels. A point at least 2 cm cephalad to the anterior superior iliac spine and at least 2 cm lateral to the rectus sheath is generally a safe starting point for placement choice.

Upper abdominal lateral port placement becomes more important to the surgical procedure as uterine size increases. When used, they should be placed cephalad almost at the level of the camera port, approximately halfway between the midline and the plane of the lower abdominal ports, again taking care to avoid the inferior epigastric vessels. These should be placed medial enough to assist with both ipsilateral and contralateral surgical maneuvers and/or retraction and to provide adequate triangulation for suturing (**FIG. 24.1A**). In the case of larger uteri that extend near or beyond the level of the umbilicus, the entire port array can be simply displaced superiorly enough to accommodate adequate vision and access (**FIG. 24.1B**).

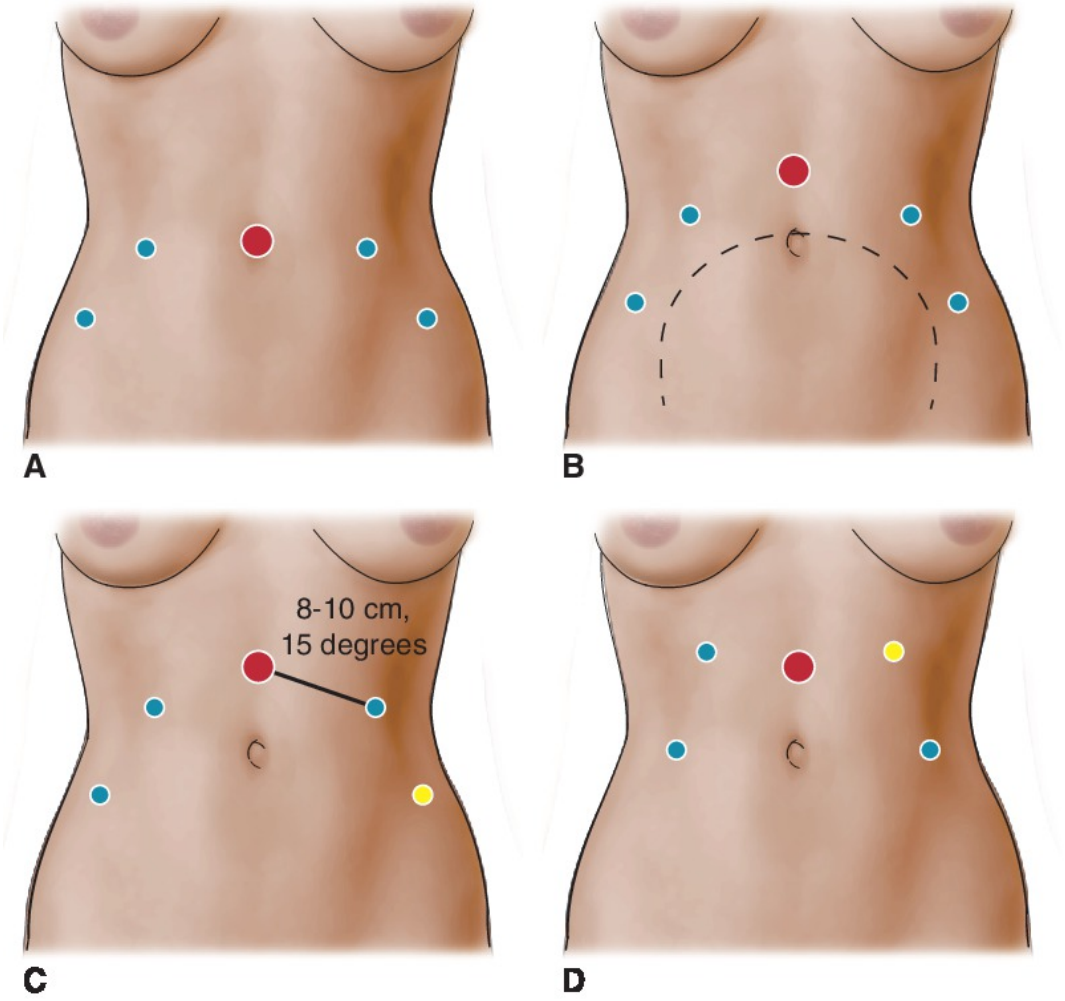



**FIGURE 24.1** Port placement. Typical port placement for TLH or LSH of a small uterus **(A)** can be displaced cranially **(B)** in the case of an enlarged uterus (*dashed line*) near or above the umbilicus. Port placement for RA-TLH can assume a "rainbow" configuration **(C)** or an "M" configuration **(D)** using secondary ports for either two or three robotic arms. Robotic ports should be placed 8-10 cm apart to avoid clashing of the robotic arms. An accessory port is generally placed for use by

a surgical assistant on the patient's left (as shown) or right (using mirror image port placement). Camera port (*red*), secondary or robotic arm ports (*blue*), accessory port (*yellow*).

It is usually helpful for at least one port to be a 10- to 12-mm size (often the midline port) to allow placement of a 10-mm laparoscope, pass suture, introduce adhesion barriers, or pass specimen bags for tissue removal. In most cases, all other ports can be 5-mm size to minimize postoperative pain and reduce the chance of trocar-site hernia. In addition to using 10-mm angled telescopes, using a 5-mm straight, angled, or flexible telescope through well-positioned accessory ports at different times during the procedure can be very useful to increase visualization of the operative field. A similar port placement strategy is employed for RA-TLH, but greater attention must be paid to the distance and angles between ports to avoid clashing of the robotic arms. The first port is the midline camera port. If the patient has a small uterus, the surgeon can plan to place the camera port 18 cm cephalad to the pubic symphysis. However, if the patient has an enlarged fibroid uterus, the camera port needs to be placed farther cephalad to allow for adequate visualization.

For initial abdominal access, the surgeon may elect to insufflate the abdominal cavity using a Veress needle. Alternatively, a Hassan approach or an optical-direct entry may be used, depending on the experience and comfort level of the surgeon. Once peritoneal placement is confirmed, carbon dioxide is insufflated to achieve a pressure of 15 mm Hg. It is essential that the patient be insufflated completely prior to measuring and marking the other port sites.

## Port Placement for Robotic-Assisted Laparoscopy

Many of the principles and techniques for initial access to the abdomen and placement of subsequent ports utilized in laparoscopic hysterectomy also apply to the robotic hysterectomy approach. However, greater attention must be paid to the location of ports and angles between ports to avoid interference of the robotic arms that may limit operative access and maneuvers. The first port is the midline camera port. If the patient has a small uterus, the surgeon can plan to place the camera port 18 cm cephalad to the pubic symphysis. However, if the patient has an enlarged fibroid uterus, the camera port needs to be farther cephalad to allow for adequate visualization. There are multiple options for lateral port number and orientation. One may elect to place ports for two or three robotic arms, depending on specific operative requirements and the model of the robotic platform. An accessory port is almost always placed to be used by a beside surgical assistant, but whether this is on the right or the left, or in the upper or lower abdomen, is dependent on surgeon preference and needs. The lateral ports and accessory port can be placed utilizing either a “rainbow” or “M” configuration (**FIG. 24.1C, D**). The fulcrum of each port must be at the level of the fascia to avoid tissue damage; the appropriate insertion level is indicated by a black line on the trocar sheath.

Objective guidelines for optimal laparoscopic port placement are limited; the decision is usually influenced more by habit than logic. Importantly, although a surgeon may be comfortable with a particular port distribution, there needs to be flexibility in number and location of ports to accommodate procedure, pathology, and preference. Adding one or two more strategically positioned ports does not contribute significant morbidity but may dramatically improve the ergonomics of the procedure and reduce surgical time.

Once the ports are placed, the patient is placed in steep Trendelenburg position, and the abdomen and pelvis are visualized prior to docking. It is essential that the patient be in steep Trendelenburg position prior to docking the robot. The tilt of the table cannot be altered while the robot is docked. The robotic patient-side cart is moved into position, which can either be located between the legs (“end docked”) or at the side of the patient (“side docked”). Once the robot is in position, the camera arm is moved into position

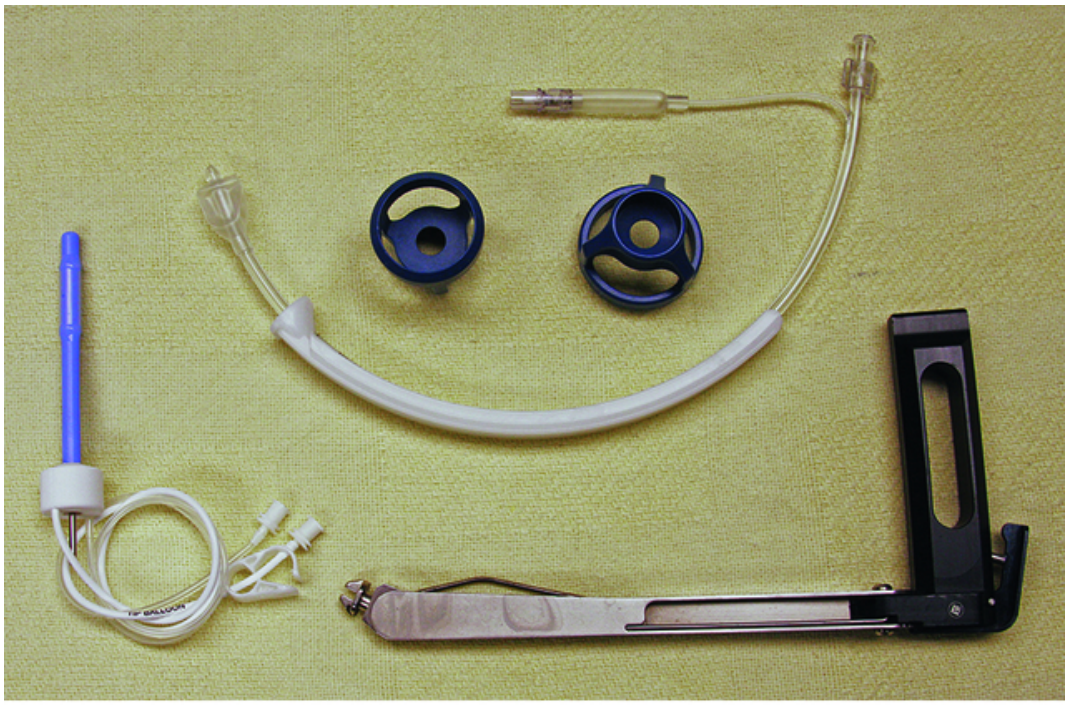
and attached to the trocar. Each of the other arms is then moved into position and docked, making sure that adequate room and angulation exists between arms to prevent collisions during the procedure. The robotic binocular camera is introduced, secured, focused, and used to watch the introduction of each of the other instruments and to ensure that the fulcrum of each trocar remains at the level of the fascia and does not move during manipulation and docking. The instruments should be placed into the central field of view such that all instruments are clearly visualized in view of the camera. At this point, the surgeon breaks scrub and moves to the console to perform the procedure.

# Uterine Manipulation

Selection of the ideal device for uterine manipulation depends on the nature of the hysterectomy being performed (TLH, LSH, or RA-TLH), the uterine size, and occasionally the patient size. The larger the uterus, the less effective any uterine manipulator will be in true manipulation of the uterine corpus, and greater reliance will be placed on instruments placed through primary and especially secondary accessory ports. For LSH, delineation of the vaginal fornices and maintaining pneumoperitoneum after a colpotomy incision are not primary concerns; a Hulka tenaculum or Valtchev manipulator is usually adequate. However, both features are critical in performing TLH or RA-TLH, where the colpotomy ring lateralizes and protects the ureters and identifies the vaginal fornices as a guide for colpotomy. A pneumo-occluder, which may be incorporated into the design of the manipulator or may be added as a separate component, maintains the pneumoperitoneum after colpotomy and amputation of the specimen from the vagina is performed and until the cuff is closed.

Choice of manipulator contributes significantly to ease of operation and shorten operating time. A wide variety of choices are commercially available. Selection of a specific combination of devices may vary with surgeon preference and experience. Choosing the appropriate straight or curved manipulator and the right size and shape colpotomy ring for manipulation of the cervix

and fornix and for removal of the uterus from the vagina is critical to success and safety (**Fig. 24.2A-C**).



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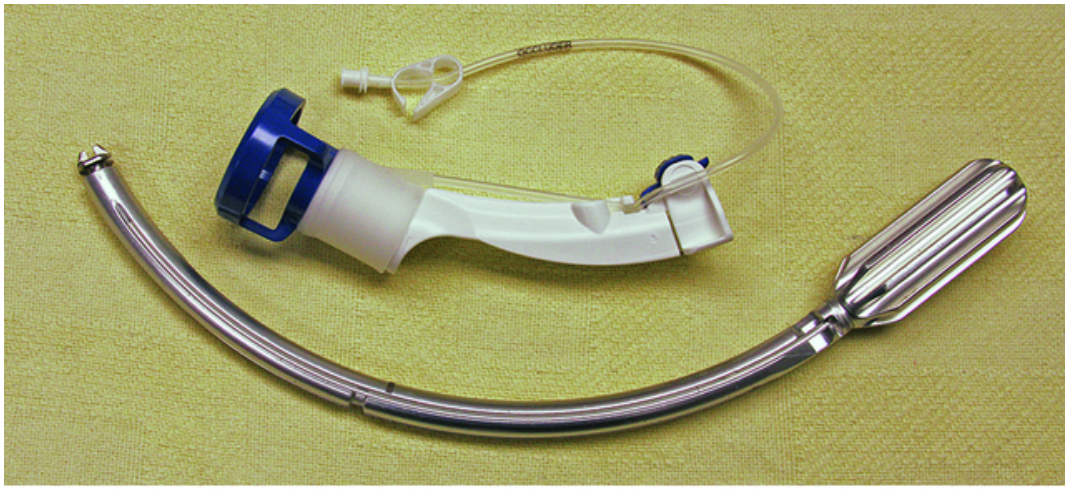

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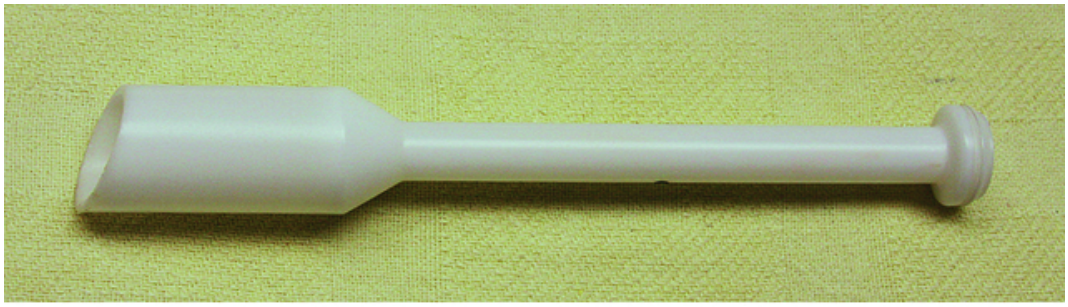

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**FIGURE 24.2** Uterine manipulator examples. **A.** ZUMI curved uterine manipulator (*top*) with different sizes of Koh colpotomy rings and RUMI straight uterine manipulator (*bottom*) with attachable uterine probe. **B.** Advincula arch uterine manipulator with Koh-Efficient colpotomy ring, including attached pneumo-occluder. **C.** ColpoProbe. (Courtesy of CooperSurgical, Inc.)

# OPERATIVE TECHNIQUE

It is useful to think of the minimally invasive hysterectomy, whether performed laparoscopically or robotically, as having five components: (1) separation of the adnexal structures from the uterine corpus for preservation or from the abdominal wall for subsequent removal; (2) dissecting, occluding, and dividing the blood supply prior to extirpation of the uterine corpus; (3) transection of the cardinal ligament complex with colpotomy and amputation of the cervix from the vaginal apex; (4) removing the specimen; and (5) closing the vaginal cuff, with or without colposuspension. For LSH, the first two components are identical to TLH and RA-TLH. However, for LSH, step 3 involves amputation of the uterine corpus from the cervix above the cardinal ligament, step 4 incorporates fewer options, and step 5 is not needed. In the case of TLH or RA-TLH for a very large

fibroid uterus, or in the case of significantly distorted anatomy in benign disease, it may be helpful to perform an LSH first (in the absence of endometrial neoplasm) and then address the colpotomy and cervical amputation with the uterine corpus out of the operative field. All the steps of laparoscopic hysterectomies mimic or correlate with comparable steps in AH. However, there are some options for modification owing to the increased magnification and proximity of visual field to the surgical target (**BOX 24.1**; **VIDEO 24.1**).

## BOX 24.1 STEPS IN PROCEDURE

- Place the patient in lithotomy position.
- Secure the patient to the operative table.
- Optimize positioning and padding of the arms and legs.
- Perform tilt test to ensure stability of the patient on the table.
- Prep and drape the patient creating the sterile field.
- Place uterine manipulator, colpotomy ring, pneumoperitoneum occluder (depending on the procedure), and Foley catheter.
- Peritoneal insufflation and port placement depending on the size of the uterus.
- Identification of anatomic landmarks, including the ureters, uterosacral ligaments, bladder edge, and colpotomy ring.

### Ovarian Preservation

- Coagulate and transect proximal fallopian tube(s) and utero-ovarian ligament(s) to separate adnexal structures from uterine corpus.

### Salpingo-Oophorectomy

- Isolate, coagulate, and transect infundibulopelvic ligament.
- Coagulate and transect mesosalpinx (if only salpingectomy is desired).

- Coagulate and transect round ligament and dissect broad ligament to the level of the uterine isthmus.
- Create bladder flap and skeletonize uterine vessels.
- Coagulate uterine vessels at the level of the colpotomy ring.
- Transect cardinal ligament and amputate the uterus and cervix from the vaginal apex, using colpotomy ring as a guide, with monopolar continuous (cutting) current.
- Remove the adnexal tissue intact and uterus.
- Close the vaginal cuff incorporating the uterosacral ligaments.
- Secure hemostasis and close trocar sites in usual fashion.

### Supracervical Hysterectomy

- Coagulate uterine vessels at the level of the uterine isthmus.
- Amputate the uterus from the cervix at the level of the isthmus.

Prior to starting the hysterectomy, the upper abdomen should always be inspected by turning the camera cephalad. In the case of RA-TLH, this is generally completed prior to docking the robot. Any adhesions may be lysed either before or after the robot is docked. The bowel should be gently moved to the upper abdomen until adequate visualization is obtained.

## The Adnexa

Regardless of the intent of preserving or removing adnexal structures, it is generally expedient to begin the laparoscopic hysterectomy by separating ovaries and fallopian tubes from the uterine fundus. This serves two distinct purposes. First, and most obvious, with this approach, the adnexa are not dangling from the corpus for the remainder of the procedure, potentially obscuring visual and operative access while securing the uterine vessels, amputating the uterine corpus (LSH), or performing a colpotomy (TLH). Second, and less appreciated, any subsequent procedure involving the adnexa can be deferred until the uterus can first be

removed from the operative field. This provides unencumbered views of, and access to, the pelvic sidewall from both ipsilateral and contralateral approaches, thus facilitating even the most challenging of adnexal procedures involving distorted anatomy, adhesions, or endometriosis.

As with AH, separation of the adnexa from the uterus can be accomplished by coagulating and dividing the round ligament first, dissecting the retroperitoneal space beneath the broad ligament to identify and isolate the ureter, then sealing and dividing the proximal fallopian tube and utero-ovarian ligament. With a laparoscopic approach, the ureter can usually be identified through the intact peritoneum crossing the pelvic brim at the bifurcation of the external and internal iliac vessels and coursing across the pelvic sidewall inferior to the infundibulopelvic ligament but superior to the uterosacral ligament (**FIG. 24.3**). If this is the case, a retroperitoneal dissection at this point in the procedure does not add any benefit to the laparoscopic hysterectomy and might result in unnecessary bleeding. Accordingly, while keeping the location of the ureter in view, the proximal fallopian tube and the utero-ovarian ligament can be coagulated and transected, preferably from the contralateral side (**FIG. 24.4A**). Tissue transection is continued parallel to the round ligament until the adnexa are completely isolated from the uterine corpus (**FIG. 24.4B**). Next, the round ligament is coagulated and transected, thus entering the broad ligament for subsequent dissection of the uterine vessels (**VIDEO 24.2**).

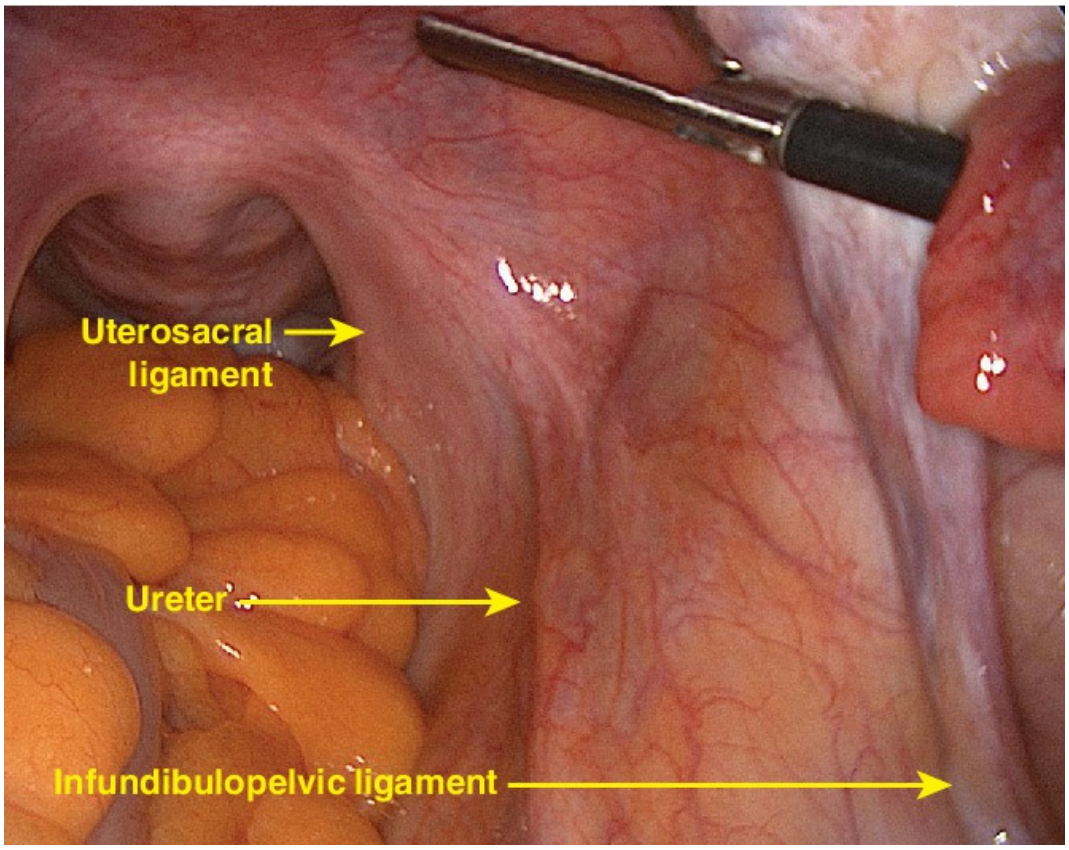
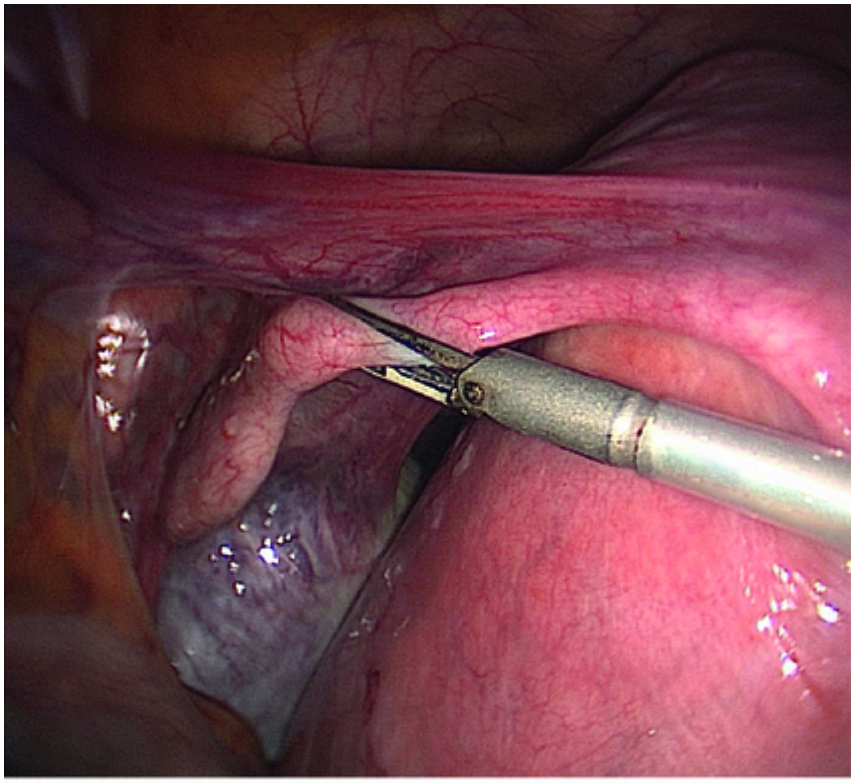



**FIGURE 24.3** Identification of the ureter. Through the peritoneum the ureter can usually be identified crossing the pelvic brim and coursing across the pelvic sidewall inferior to the infundibulopelvic ligament and superior to the uterosacral ligament. Understanding and identifying this anatomic relationship can prevent the need for retroperitoneal dissection for ureter identification prior to adnexectomy.



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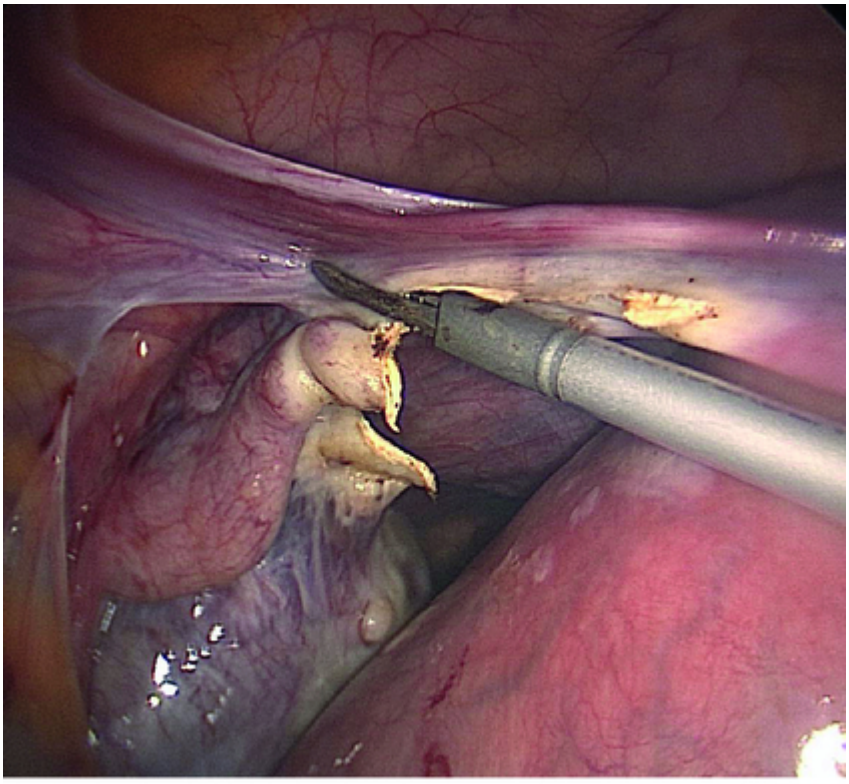

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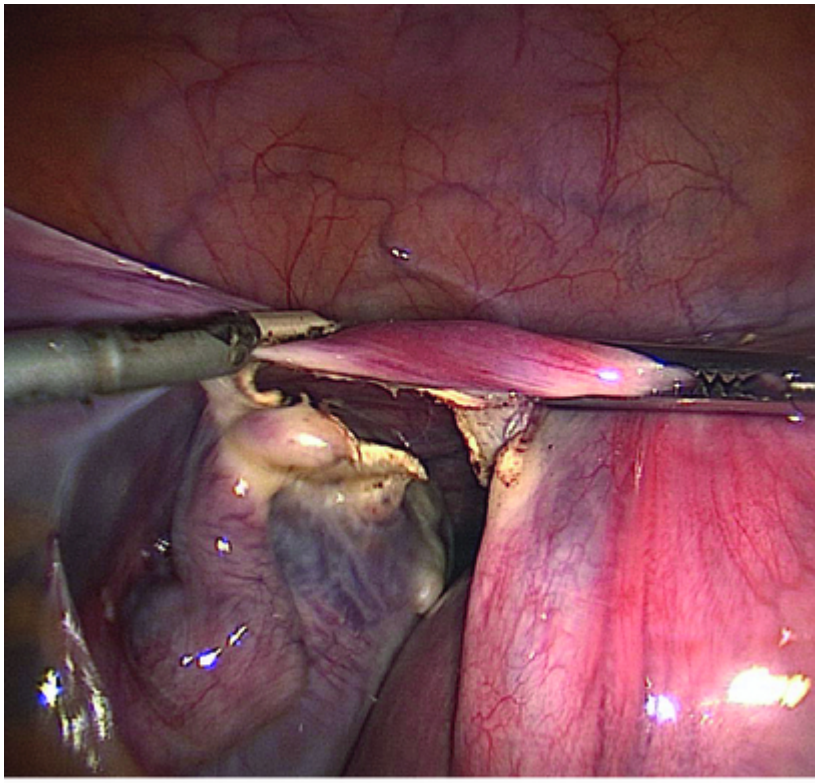

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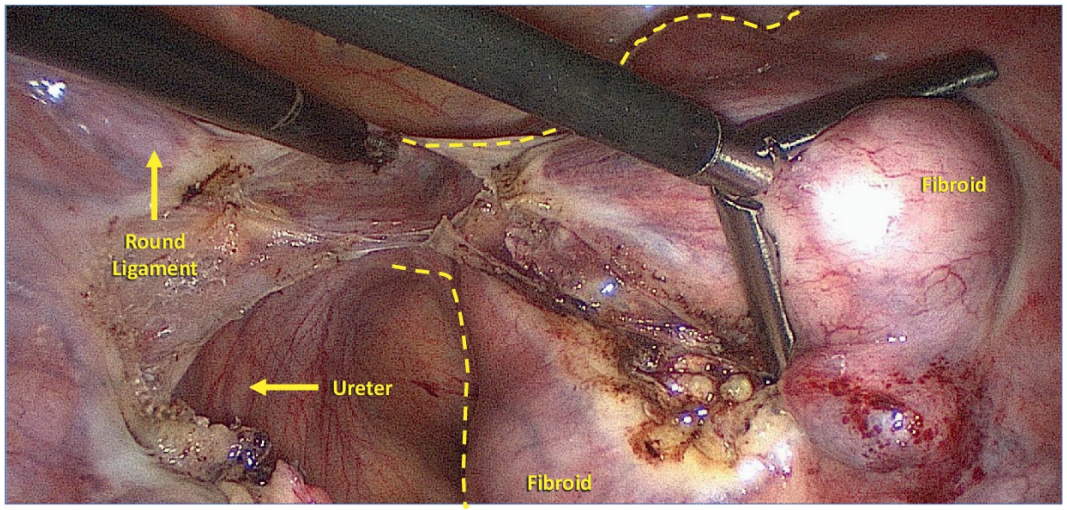



D

**FIGURE 24.4** Isolate adnexal structures. The proximal fallopian tube **(A)** and utero-ovarian ligament **(B)** are usually best transected from the contralateral approach. The round ligament is best transected from the ipsilateral

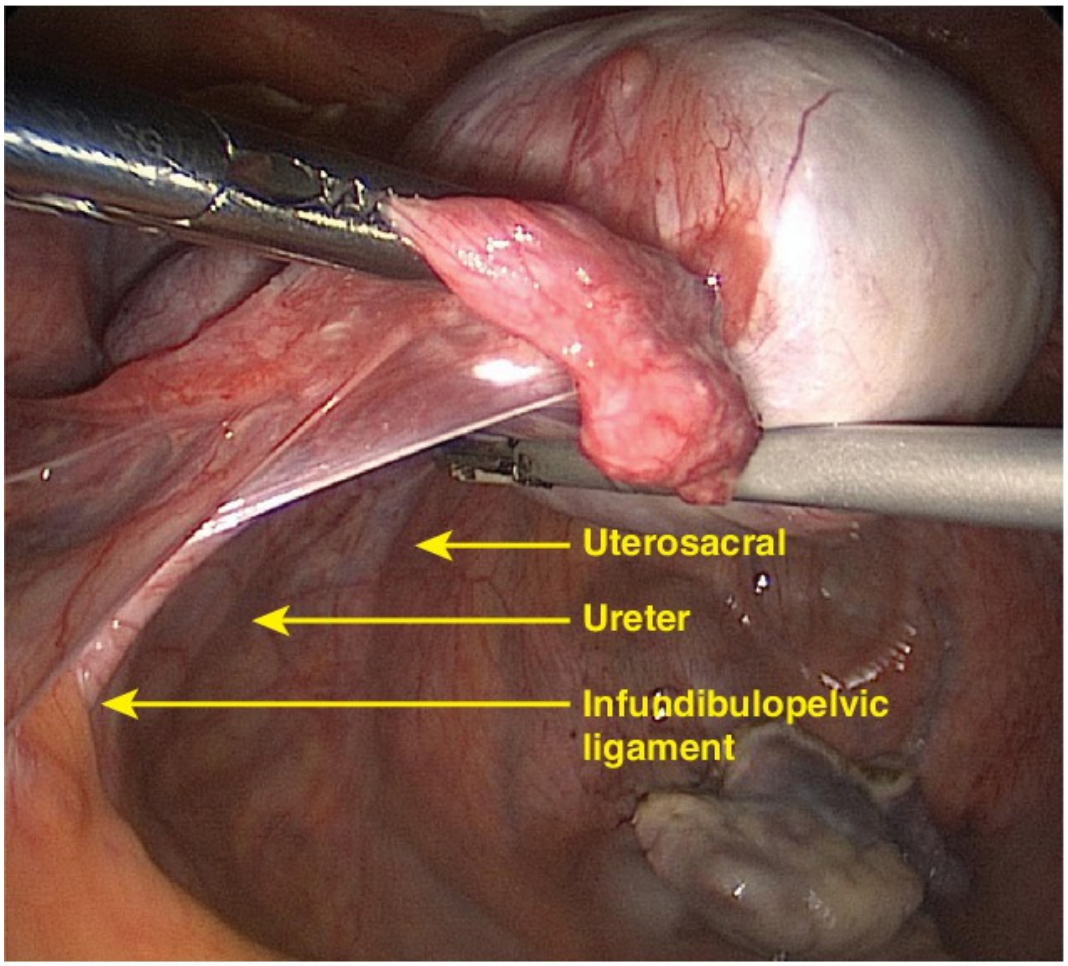
approach **(C)**. Retraction for transection of the round ligament and subsequent dissection of the broad ligament space can be accomplished from either a contralateral or an ipsilateral approach **(D)**, depending on the size of the uterus and port placement. In panel **(D)**, everything to the right of the dotted line is an enlarged fibroid uterus. An atraumatic grasper is seen straddling a lateral uterine fibroid and pushing the uterus toward the midline to gain access into the broad ligament.

If the uterus is small enough, or if secondary accessory ports have been placed high enough, the round ligament should be grasped from the contralateral side to retract the uterus medially and stabilize the round ligament. The round ligament is coagulated, and the leaves of the board ligament are opened to enter the retroperitoneal space and subsequent dissection within the broad ligament can then be accomplished from an ipsilateral approach (**FIG. 24.4C**). In cases where the uterus is larger, distorted by fibroids, or otherwise conformed in a manner where retraction using instruments through the contralateral ports is suboptimal, “retraction” can be attained by pushing the uterus medially using an instrument through one ipsilateral port and coagulating, cutting, and dissecting through the other ipsilateral port, as illustrated in **FIGURE 21.4D**. Note that the blades of the grasper are opened to add stability to the “retraction,” which can be aided by using existing features of the uterus (in this case a fibroid). Although it cannot be fully appreciated in this image, the “retracting” instrument has been placed through the left primary (lower) accessory port for optimal manipulation of the uterus both cephalad and medial. The instrument used for manipulation,

coagulation, and cutting has been placed through left secondary (upper) accessory port to achieve the best angle for dissection of the broad ligament toward the uterine isthmus.

In cases of distorted anatomy, the more traditional approach of entering the retroperitoneal space by incising the round ligament, identifying the ureter, and dissecting its course toward the uterine artery prior to isolating the adnexal structures is preferred.

If the goal is ovarian preservation, the adnexa can be ignored at this point. Alternatively, when the intent is to remove the fallopian tubes and/or ovaries, to treat benign ovarian pathology (eg, remove a dermoid cyst or endometrioma), and/or to address pelvic sidewall issues (eg, adhesions or endometriosis), this action can usually be deferred until after the uterine corpus is out of the way. At that time, the mesosalpinx or the infundibulopelvic ligament can be isolated, coagulated, and transected. Ergonomically, it is preferable to retract the adnexal structures medially from the ipsilateral side while securing and transecting the pedicles from the contralateral side (**FIG. 24.5A, B**). This approach permits an application of the energy source perpendicular to the pedicle, which maximizes efficient performance of the instrument and minimizes collateral thermal tissue damage.

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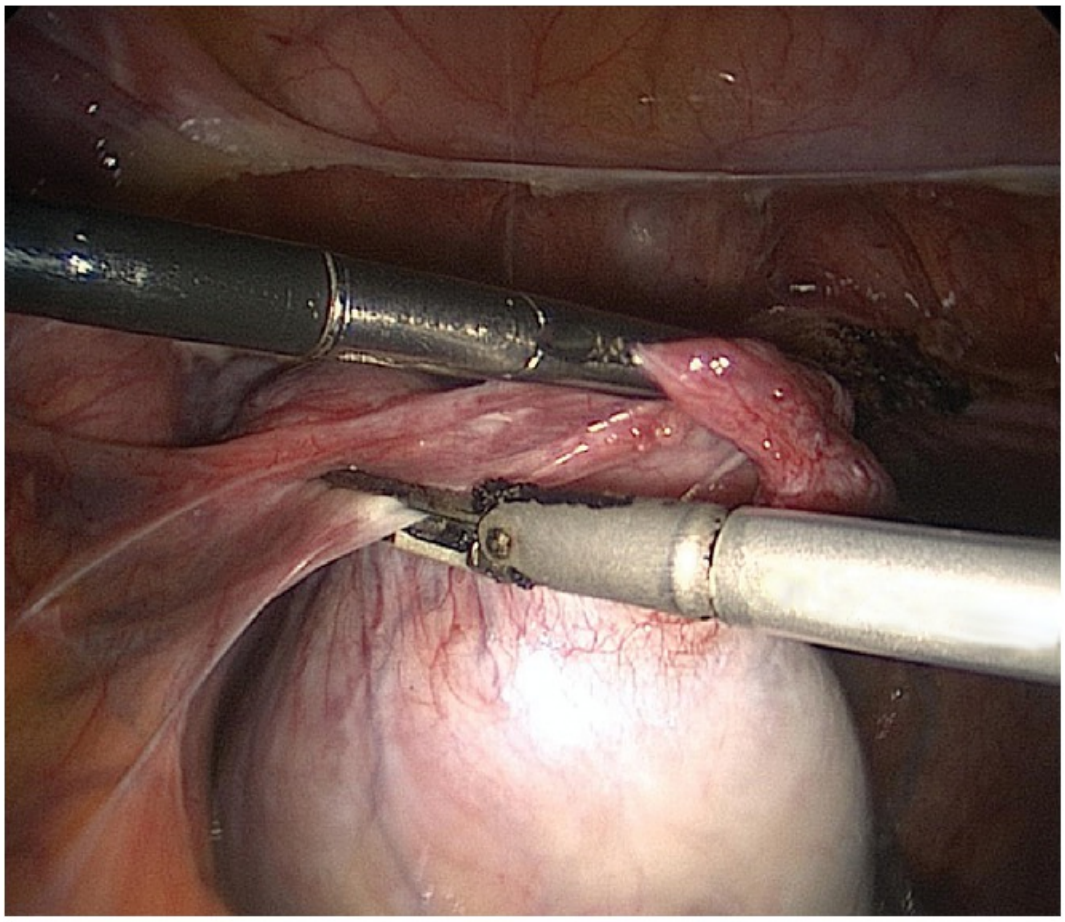


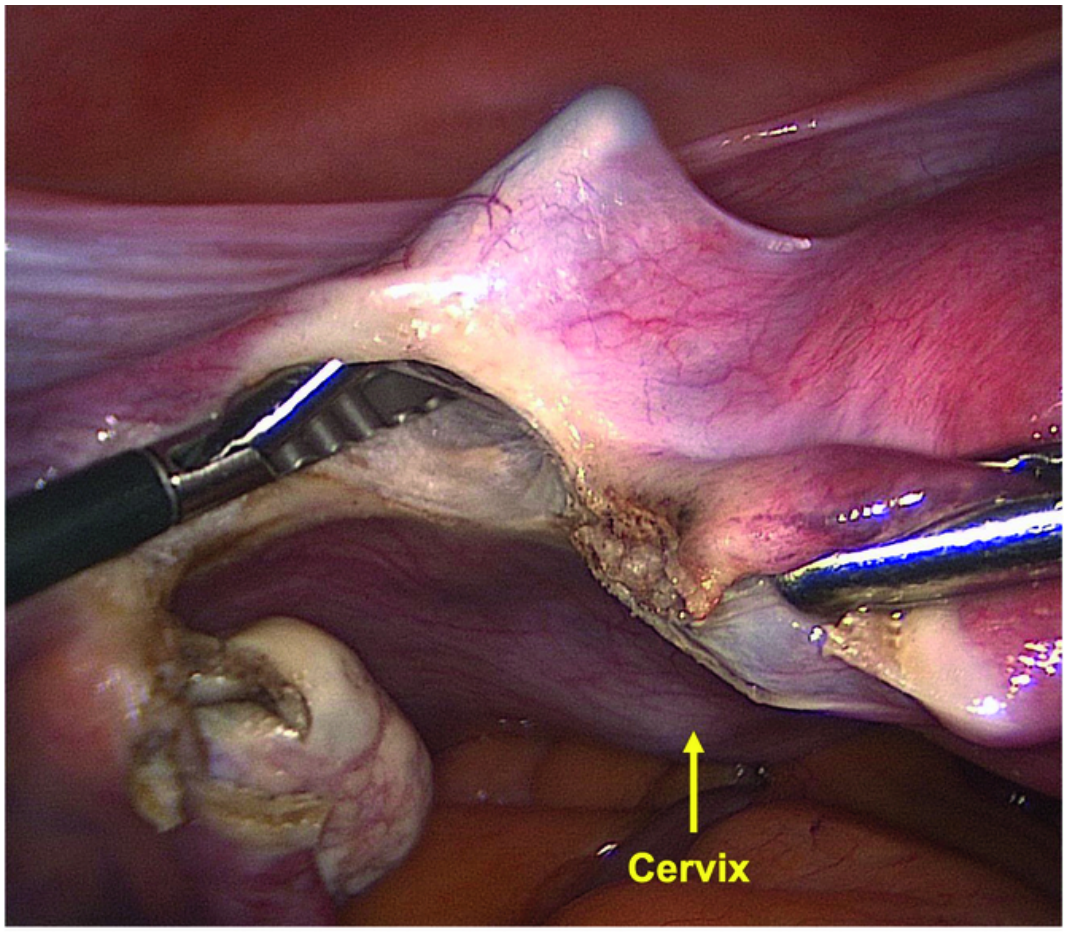
B

**FIGURE 24.5** Salpingo-oophorectomy. After removal of the uterine corpus, there is unobstructed access to the adnexal structures. The infundibulopelvic ligament is easily distinguished from the ureter **(A)** for safe coagulation and transection **(B)**.

In the case of an ovarian or uterine neoplasm where removal of the uterus intact with adnexal structures attached is preferred, a reversal of the order of these steps can be applied: identification of the ureter retro- or transperitoneally, coagulation and transection of the infundibulopelvic ligament, and subsequent transection of the round ligament.

# The Uterine Corpus and Vessels

Once the round ligament has been transected, the anterior and posterior leaves of the broad ligament are easily separated. Dissection is continued in this avascular plane toward the junction of the cervix and the uterine corpus. Further transection of the anterior leaf of the broad ligament continues across the cervix to develop the bladder flap (**FIG. 24.6A**). Importantly, cold sharp dissection (or only very brief pulses of bipolar current to maintain hemostasis of superficial peritoneal vessels) is preferred when developing the bladder flap until the anatomic limits of the bladder are defined. The loose areolar tissue between the leaves of the broad ligament can be teased away bluntly or sharply to reveal the uterine vessels on the lateral aspect of the uterus (**FIG. 24.6B**). This careful isolation and skeletonization of the vessels allow for selective vessel sealing and transection with minimal potential for collateral thermal or mechanical tissue damage. These steps are identical to their AH counterparts.

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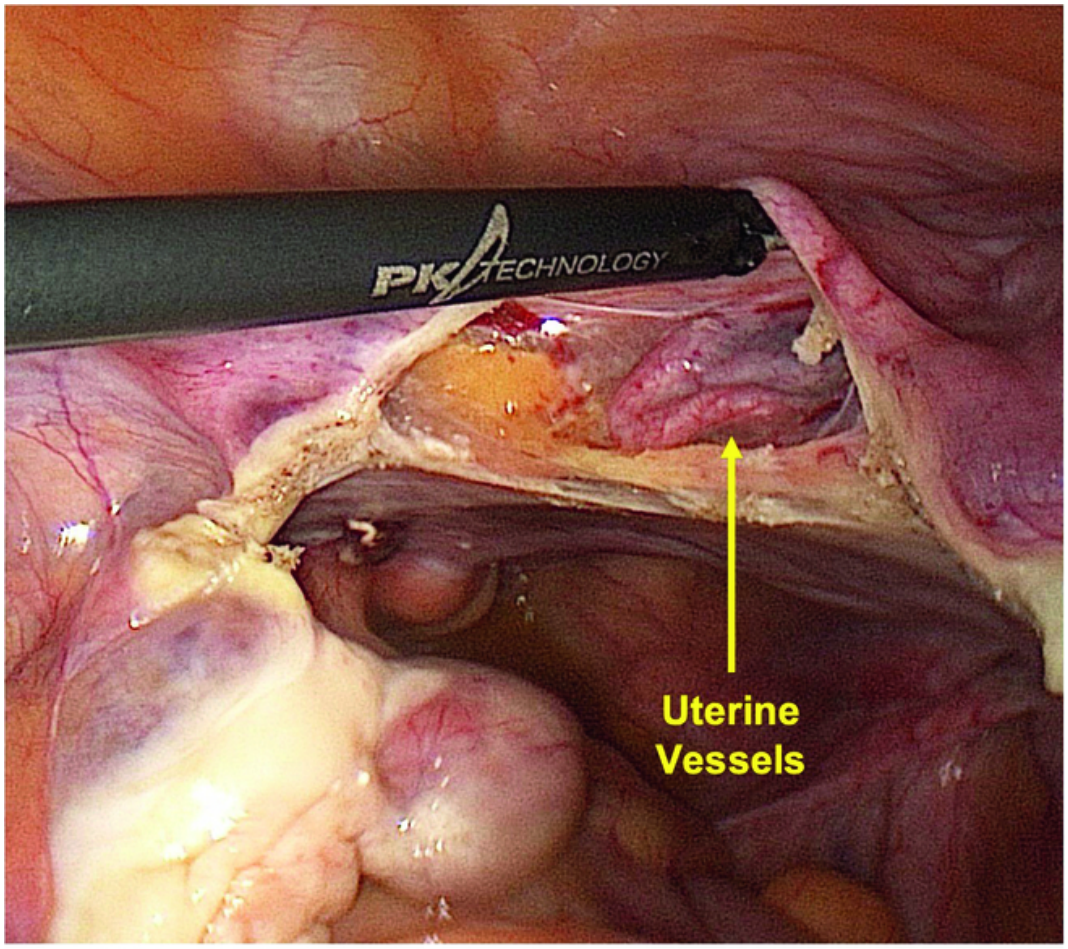



B

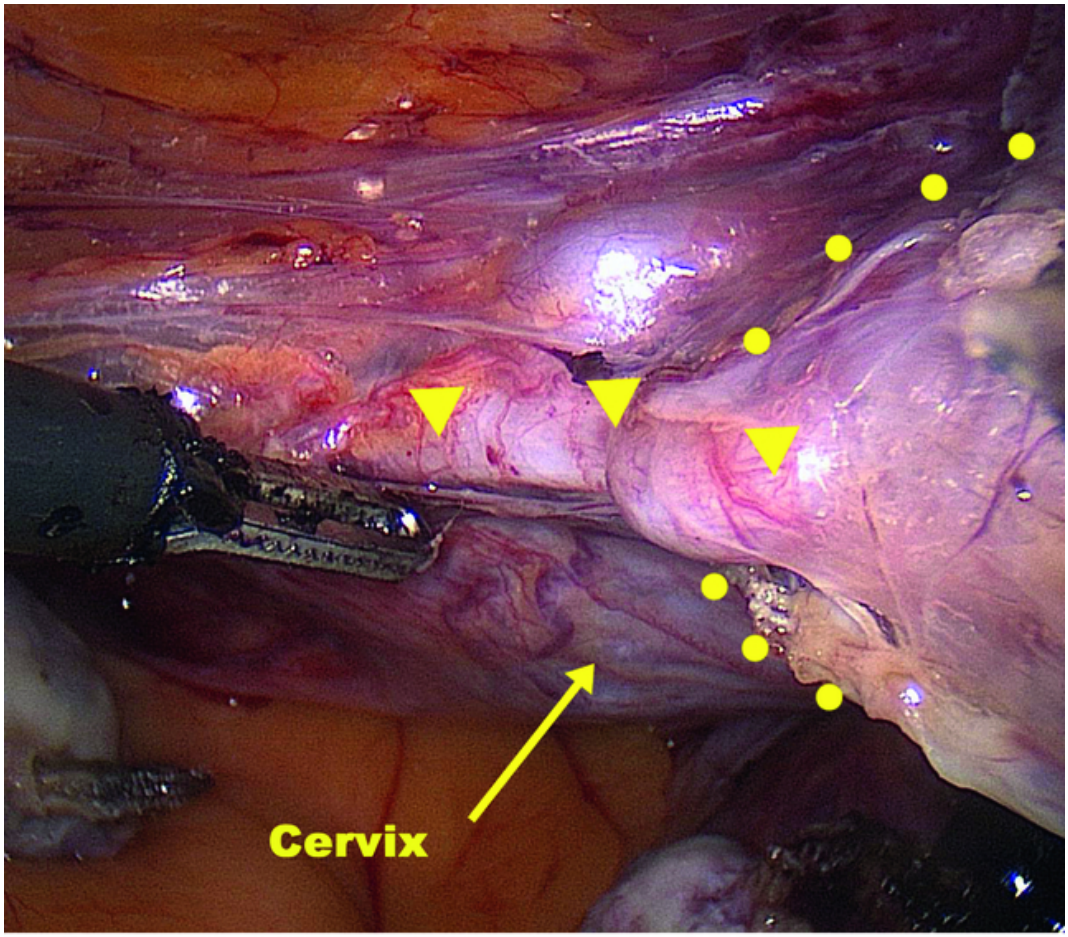
**FIGURE 24.6** Creation of bladder flap and amputation of the uterus. The anterior and posterior leaves of the broad ligament are separated to create a bladder flap **(A)**, which allows the surgeon to expose and skeletonize the ascending uterine vessels **(B)**.

When skeletonizing, coagulating, and transecting the uterine vessels, retraction of the uterus from the contralateral side is preferred as this allows the more efficient use of two operative instruments by the surgeon. However, in situations where contralateral retraction is not possible, the ipsilateral retraction

technique described above can be employed. Either way, care should be taken not to twist the uterus, which can distort the anatomy and disorient the surgeon. It is still possible to accomplish these maneuvers effectively even if only one operative instrument is employed. Most advanced electrosurgical instruments used in laparoscopic procedures today are designed to permit tissue dissection, sealing, and transection using the single instrument. A skilled experienced surgeon can use a single instrument to develop the bladder flap and skeletonize, coagulate, and transect the uterine vessels. Understanding the specific properties of your electrosurgical instrument is critical.

# Colpotomy

When performing LSH, the ascending branches of the uterine vessels should be coagulated and transected at the junction of the lower uterine segment with the cervix (**FIG. 24.7A**). This is also the level at which the uterus is amputated from the cervical stump. This is perhaps the most critical step in performing LSH. The optimal level of vessel transection and fundal amputation can be identified in most uteri where the curvature of the fundus “flattens out” onto the cervical isthmus. It is important to coagulate the uterine vessels just inferior (toward the cervix) to the intended fundal amputation plane. Coagulating the uterine vessels in an ascending manner up along the edge of the uterus will decrease back bleeding from the uterus and accentuate the angle of the junction between the uterine fundus and cervix as a guide for subsequent division of uterine vessels and fundal amputation.

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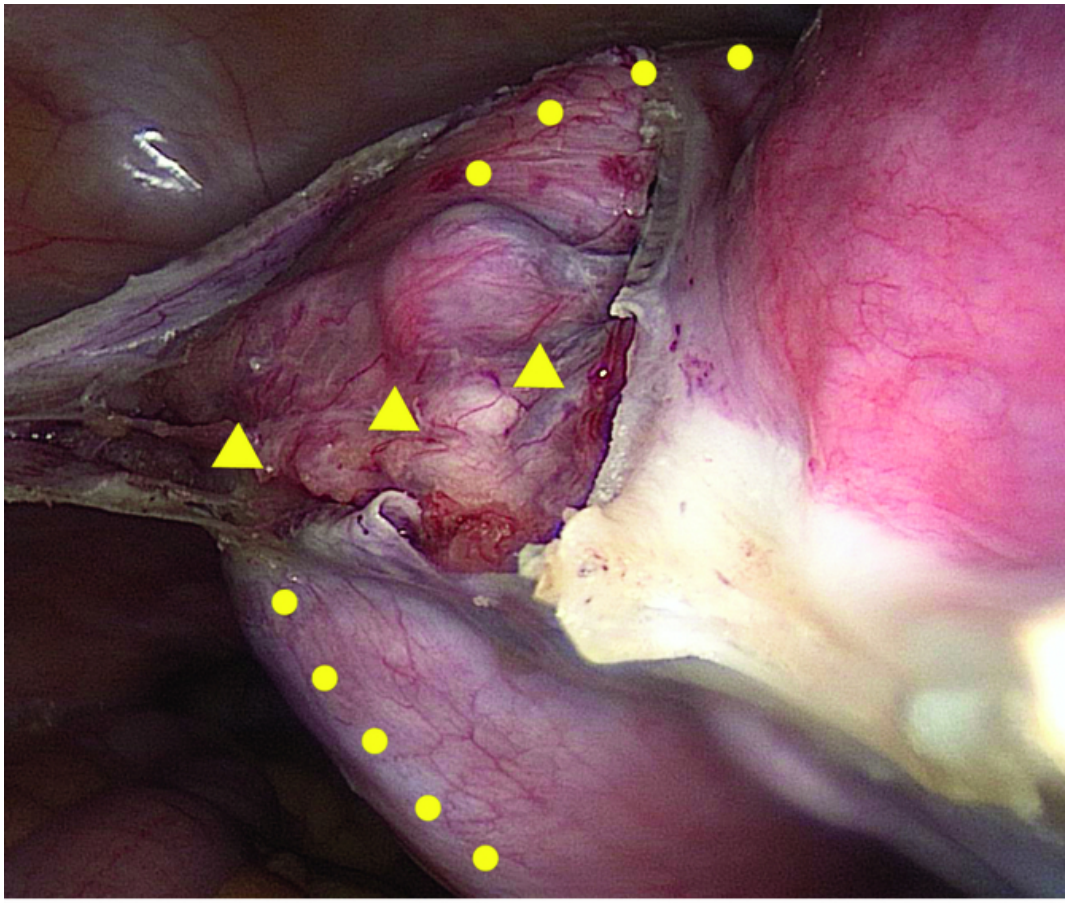


B

**FIGURE 24.7** Uterine vessels and cervical amputation or colpotomy. **A.** When performing LSH, the vessels (*triangles*) are coagulated and transected at the junction of the lower uterine segment with the cervix, and the uterine corpus is amputated by transecting the cervix at this location (*dotted line* represents plane of amputation). **B.** When performing TLH or RA-TLH, the ascending branch of the uterine vessels (*triangles*) can be coagulated and transected as they are crossing the colpotomy ring, which also serves as a guide

for subsequent colpotomy (*dotted line* indicates the colpotomy ring).

Many surgeons attempt to amputate the uterine fundus too low on the cervix due to difficulty ascertaining the optimal plane for amputation, or from a belief that excising more of the cervix will decrease the likelihood of subsequent cyclic bleeding. The incidence of post-LSH cyclic bleeding does not appear to be related to length of cervix left. However, if too much of the cervix is amputated, increased bleeding will occur because of the rich vascular supply to the cervix and upper vagina and further efforts will be required to achieve hemostasis. If electrosurgical energy is applied to address bleeding from this area, there is an increased risk of thermal injury to the ureter or compromise of the vascular supply to the remaining cervical stump, both of which are likely not to be recognized until several days after the procedure and resulting in fistula formation or necrosis of the cervical stump. To decrease this risk, the cervical stump should be elevated out of the pelvis using a sponge stick or other transvaginal manipulator and energy applied sparingly. Alternatively, other mechanisms for obtaining hemostasis could be considered, including vascular clips or suturing.

After fundal amputation, the endocervical canal is fulgurated, preferably using bipolar current, or it can be left untreated. Although it seems intuitive that fulguration of the endocervical canal would decrease the incidence of post-LSH cyclic bleeding, there is no evidence to support that belief. The probability of bleeding is more related to patient age and/or the presence of preexisting endometriosis.

When performing TLH or RA-TLH, once the bladder flap is created, the skeletonized ascending branches of the uterine vessels can be identified crossing the colpotomy ring (**FIG. 24.7B**). The vessels should be coagulated and transected at this level. As with LSH described above, this step and subsequent colpotomy and amputation of the uterus from the vagina are the most critical steps when performing any laparoscopic hysterectomy. Also, similar to the technique described for LSH, continued coagulation of the uterine

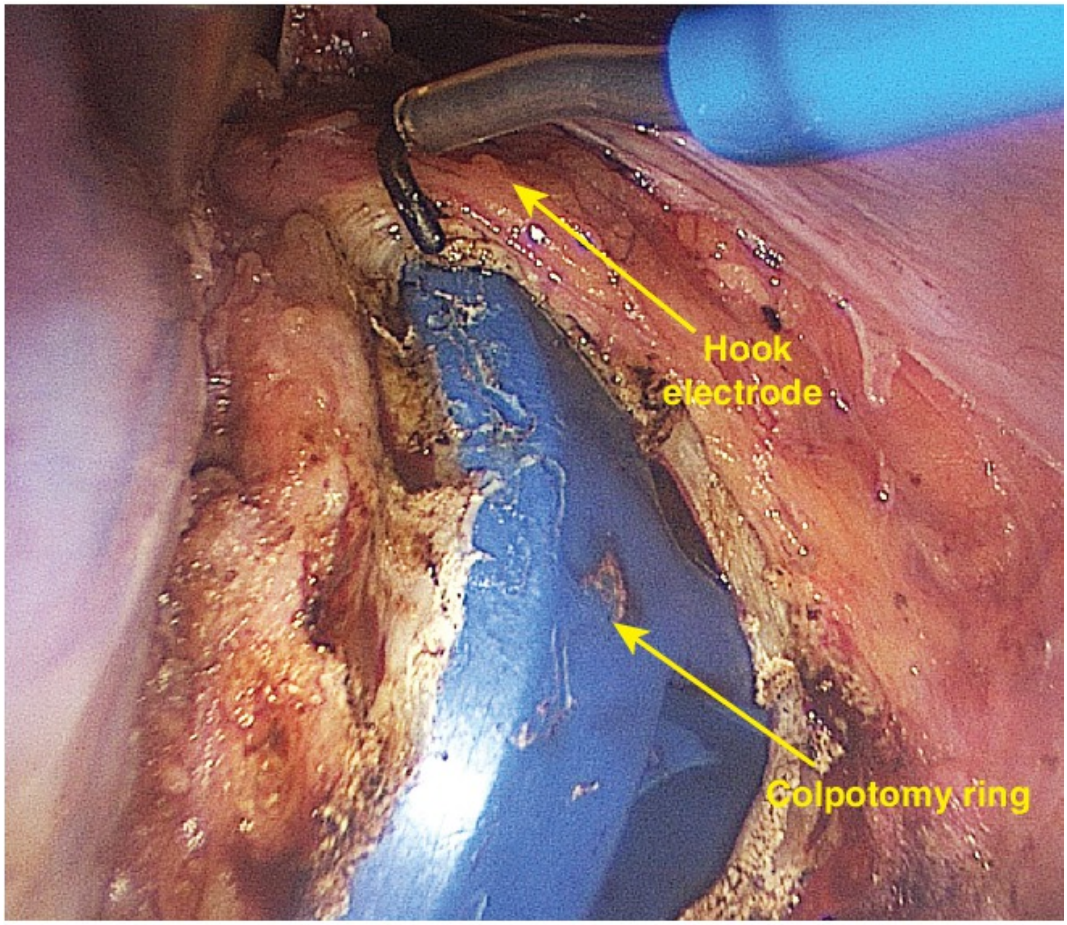
vessels in an ascending manner up the lateral edge of the uterus will decrease back bleeding from the uterus at the time of vessel transection. However, in contrast with the LSH, the presence of a previously placed colpotomy ring delineates the vaginal fornix, providing an excellent guide for exactly where to transect the vessels and exactly where to amputate the uterus from the vagina.

The colpotomy incision and amputation of the uterus are the most critical steps in performing TLH or RA-TLH. While bipolar current is typically used to coagulate the uterine vessels, a variety of instruments can be used to perform the colpotomy incision. Efforts should be made to minimize potential for electrosurgical injury at this step. A monopolar hook electrode attached to a “Bovie pencil” using continuous (cutting) current is particularly useful. Using the colpotomy ring as a backstop, it can deliver very focused electrosurgical energy with low voltage. Any oozing that is encountered can usually be handled with short bursts of monopolar discontinuous (coagulation) current. This minimizes thermal spread that results in devitalization of tissue at the cuff over time and minimizes the risk of inadvertent electrosurgical injury to the bladder or ureter.

The same procedural steps performed in a conventional laparoscopy case are followed in the robotic-assisted hysterectomy. The nondominant hand typically holds the grasper/coagulator, and the dominant hand holds the monopolar scissors. The dissection is performed in a stepwise fashion, and instrument ports are rarely if ever switched. The third arm is used for retraction of the specimen when necessary. Both sides of the specimen can be reached with the same configuration. The cervicovaginal junction is incised along the ring with the monopolar scissors.

It does not matter whether the anterior or posterior colpotomy incision is made first. It is more important to choose whichever is most identifiable and accessible so that the edge of the colpotomy ring can be identified when the tissue is divided. Once this is achieved, the amputation is simply a matter of “following the ring” circumferentially using the tip of the hook electrode (**FIG. 24.8A**). Importantly, when the colpotomy ring is placed and identified appropriately, the level of cervical amputation is at the cardinal

ligament. Thus, when the posterior colpotomy incision is made, the uterosacral ligaments remain attached to the fascia of the vaginal apex (**FIG. 24.8B**). This facilitates incorporation of the uterosacral ligaments into the subsequent cuff closure for pelvic support.

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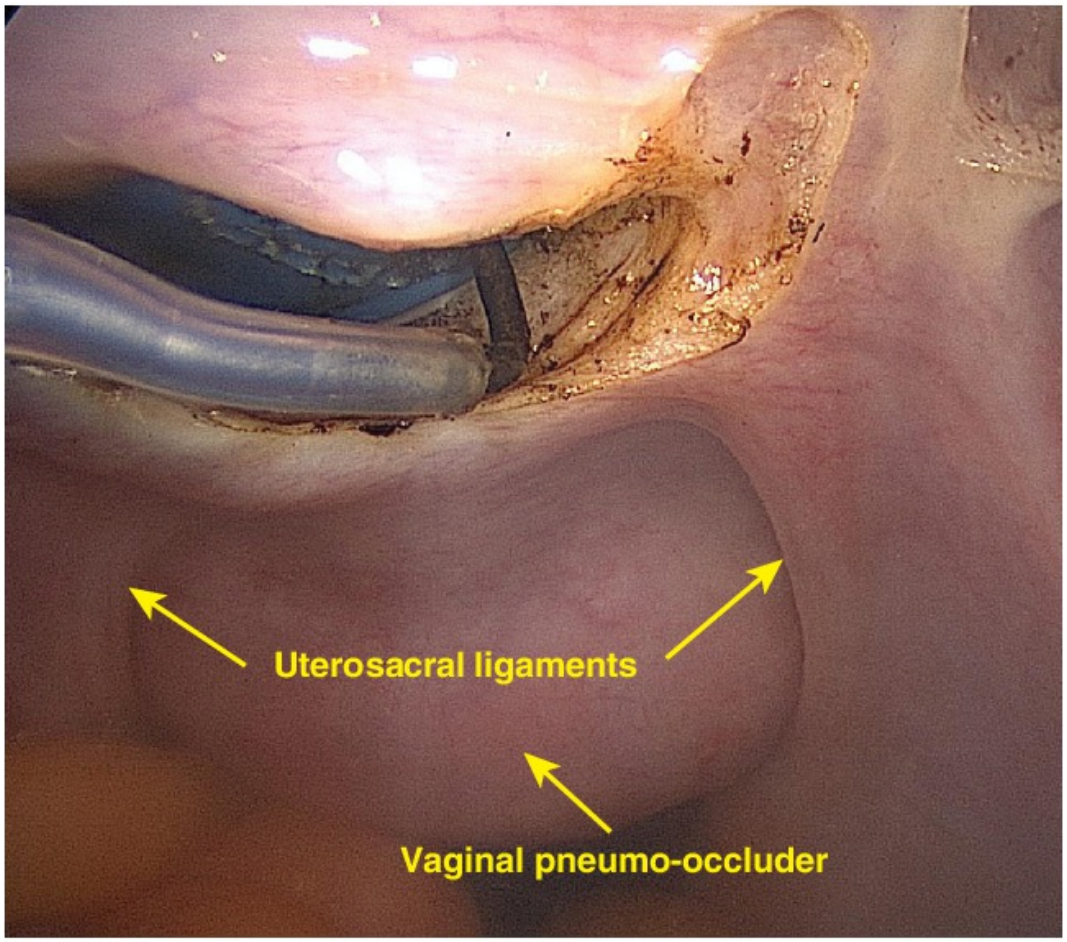



B

**FIGURE 24.8** Amputation of the uterus. **A.** A thin monopolar electrode (eg, hook) is recommended for amputation of the uterus using the colpotomy ring as a guide. This applies the lowest voltage energy and minimizes the risk of thermal injury to the ureter or bladder. **B.** Amputation of the uterus and cervix at the level of the colpotomy ring transects the cardinal ligament complex, leaving the uterosacral ligaments attached to the fascia of the vaginal apex.

In cases where the uterus is particularly bulky, or there is distortion of the pelvic anatomy due to adhesions, endometriosis, or other pathology, amputation of the fundus from the cervix can be accomplished prior to attempting colpotomy and amputation of the cervix. In fact, it is often preferable to do so. In this case, the same steps described above with LSH are followed, usually amputating even higher on the cervix or even lower uterine segment. Subsequently, the plane delineated by the colpotomy ring is easier to identify and to access for cervical amputation.

# Uterine Extraction

When performing TLH or RA-TLH, the uterus, cervix, and adnexal structures are usually removed through the vagina prior to closing the cuff. This becomes more challenging with increasing uterine size, but vaginal morcellation offers an excellent technique for removal of larger specimens. Each surgeon will have to determine his or her own skill level with respect to vaginal morcellation and the size at which alternative tissue removal techniques will need to be employed. When performing LSH, tissue removal options are more limited.

Aside from extraction of tissue through the vagina, removal options include making a small laparotomy incision to remove the tissue intact.

# Morcellation

There is significant controversy regarding the safety of tissue morcellation, particularly when a fibroid uterus is present. Use of electromechanical morcellation has been shown in some cases to widely disseminate tissue which in the rare case of an undiagnosed malignancy has disastrous consequences. Manual morcellation performed either abdominally or vaginally has not been proven to avoid this possibility; it simply has not been studied. The FDA has issued a warning against morcellating uteri containing fibroids, or just fibroids alone, due to the inability to diagnose leiomyosarcoma preoperatively. However, reviews of relevant literature by different

professional organizations, including AAGL and ACOG, support that tissue morcellation can be performed safely and effectively by properly trained and experienced surgeons in appropriately screened and selected patients. Moreover, a recent critical review of the literature by an AAGL task force suggests that the incidence of leiomyosarcoma was dramatically overestimated by the FDA, did not address the age-stratified risk of leiomyosarcoma, and did not emphasize the dire consequences of leiomyosarcoma (morcellated or not). Morcellation should not be employed when a malignant or premalignant diagnosis is known or if preoperative assessment of the patient is suspicious for the same. In these cases, tissue needs to be removed intact, even if it means making a laparotomy incision specifically for this purpose.

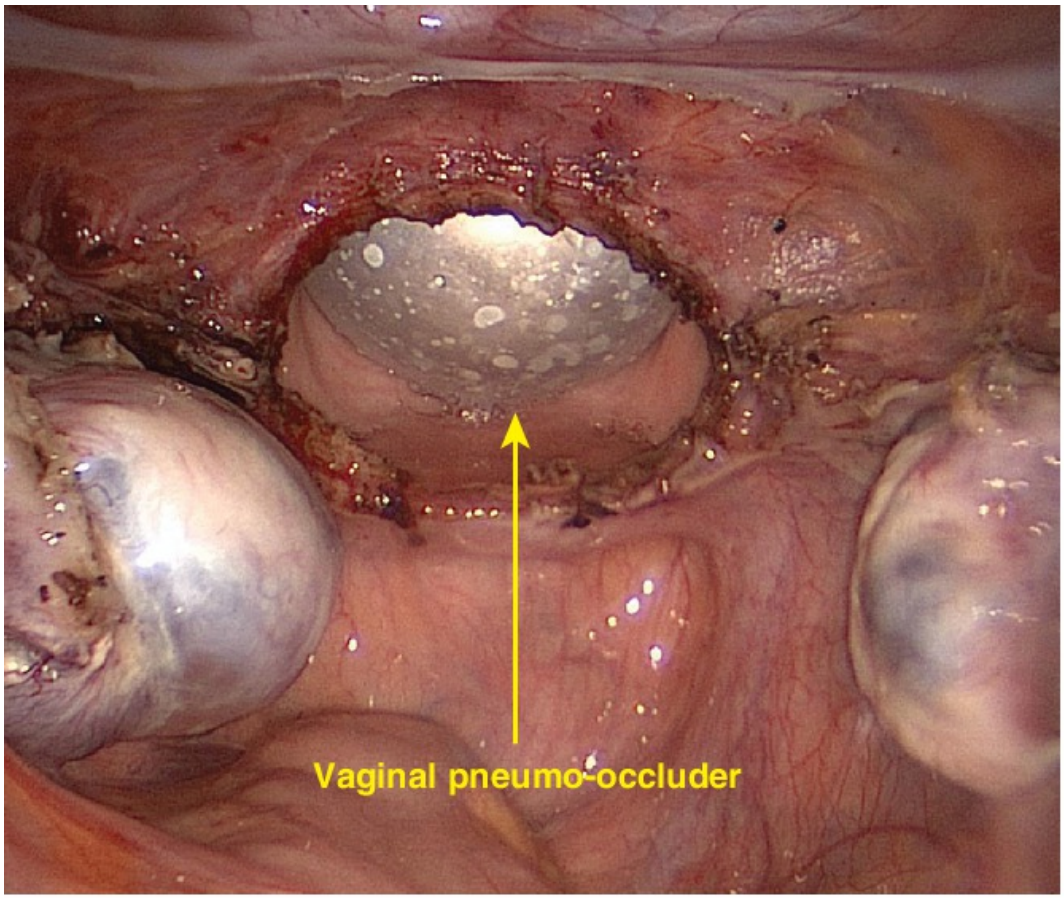
Since the issuance of the FDA statement on fibroid morcellation, considerable effort has been directed toward developing systems for contained morcellation. To perform contained morcellation, the tissue to be morcellated is first placed inside a tear-resistant bag within the abdominal cavity. With the opening of the bag pulled through a slightly enlarged laparoscopic port incision, or through a specially designed trocar, manual or electromechanical morcellation can be carried out in the same manner as described previously with the anticipation that the bag would contain spread of tissue within the abdominal cavity. At least one such system has obtained FDA approval for this activity.

Electromechanical morcellation employs a device with a hollow blade through which an instrument is passed to grasp the tissue, typically a laparoscopic tenaculum or a toothed grasper. The tissue is brought to the tip of the device and, with the blade spinning, is pulled through. Ideally, the blade is guided around the periphery of the specimen to retrieve long strips of tissue while trying to avoid coring through the middle.

## Cuff Closure

With laparoscopic hysterectomy, the vaginal cuff can be closed laparoscopically or vaginally, depending on the skill of the surgeon, but the former defines a true TLH. After the uterus has been

removed through the vagina or an alternative mechanism, a pneumo-occluder balloon, a glove with a laparotomy pad or sponge placed within, or a bulb syringe can be placed in the vagina to maintain pneumoperitoneum until the vaginal cuff is closed (**FIG. 24.9A**). When necessary, ring forceps can be introduced transvaginally around the pneumo-occluder to grasp and retrieve the ovaries and/or tubes prior to closing the vaginal cuff.

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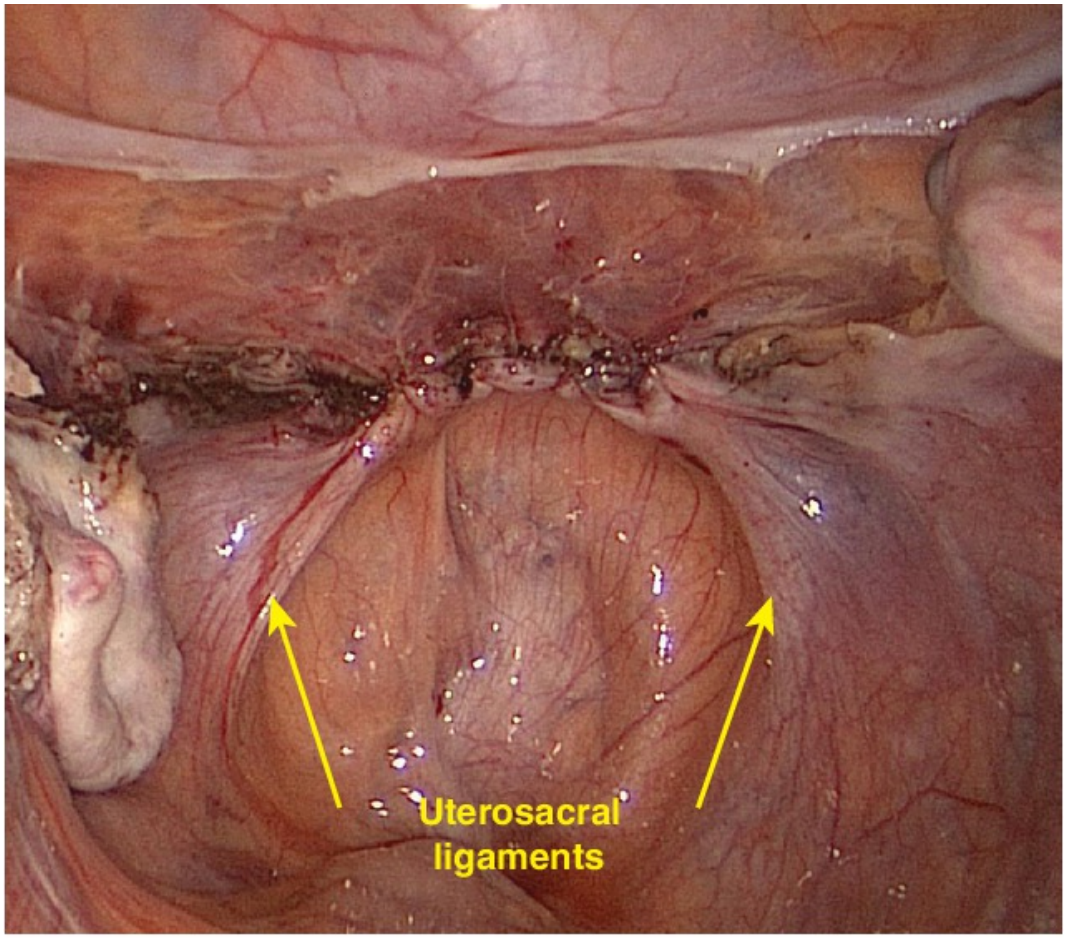


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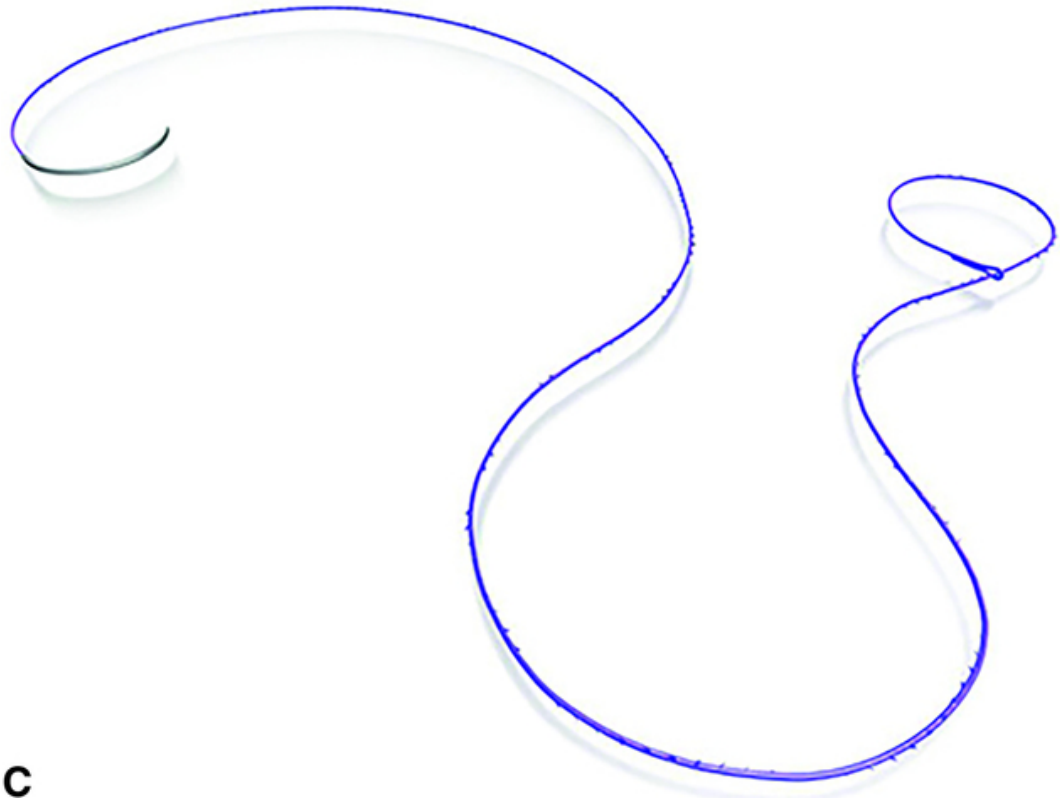

C

**FIGURE 24.9** Closure of the vaginal cuff. **A.** After amputation of the uterus, a pneumo-occluder balloon is placed in the vagina can maintain peritoneal insufflation until the vaginal cuff is closed. **B.** Cuff closure should incorporate the uterosacral ligaments. **C.** Barbed suture. 2-0 PDS is often used for closure. (©Ethicon, Inc. Reproduced with permission.)

The basic tenets of cuff closure for abdominal and vaginal hysterectomy also apply to TLH, only the visual perspective and magnification changes. Both intracorporeal and extracorporeal knot-tying techniques have been described using absorbable suture. However, the creation of unidirectional barbed suture has facilitated

laparoscopic suturing because it does not require knot tying, which is the most technically challenging and skill-limiting component. In either case, suturing proceeds from the anterior to the posterior vagina, and support is obtained by incorporating the uterosacral and cardinal ligaments (VIDEO 24.3).

Incorporation of the uterosacral ligaments into cuff closure has become relatively standard with abdominal or vaginal hysterectomy and has been demonstrated to decrease the incidence of vaginal vault prolapse from 25% to 5%. Although there have been no long-term trials to show comparable results after TLH, there is every expectation for similar outcomes, and incorporation of the uterosacral ligaments into the cuff closure is recommended (FIG. 24.9B); laparoscopy is a different access, not a different procedure (FIG. 24.9C).

# COMPLICATIONS

The nature of complications occurring with TLH is similar to those reported for abdominal and vaginal hysterectomy. Complications related to medical comorbidities, anesthesia, or the hysterectomy procedure may occur, as well as those related specifically to laparoscopy. Regardless of access, hysterectomy remains a relatively safe procedure with a mortality rate estimated between 0.12 and 0.34 per 1000 procedures.

The role of surgeon experience in reducing complications of laparoscopic hysterectomy cannot be overemphasized. Multiple studies have demonstrated decreased complication rates that plateau after about 100 cases and with high-volume laparoscopic surgeons.

## Cuff Dehiscence

Early examination of the occurrence of vaginal cuff dehiscence revealed a statistically increased incidence with TLH, as high as almost 5%. Two factors thought to contribute to the increased cuff dehiscence rate after TLH include (1) increased magnification of the surgical field with the laparoscope, leading the surgeon to think the

tissue included in the suture is more than it really is, and (2) progressive devitalization of tissue with time due to thermal effect occurring during colpotomy, possibly extending to or beyond the suture line. Multiple studies identified the greatest steps that can be taken during cuff closure to mitigate dehiscence, in addition to basic surgical principles of hemostasis and "approximation, not strangulation" of tissue, are minimizing application of thermal energy during colpotomy, incorporating adequate healthy tissue in the suture line, and a double layer closure using continuous suturing. Attention to these measures has significantly decreased the incidence (**TABLE 24.1**).

## TABLE 24.1
## Optimal Cuff Closure

| |
|---|
| Obtain hemostasis |
| Approximate tissue without strangulating |
| Apply minimal amount of thermal energy necessary |
| Incorporate adequate healthy tissue |

Cuff dehiscence may be partial or complete and may occur with or without bowel evisceration. In the absence of evisceration, it is possible to revise and reclose the cuff with a vaginal approach. However, laparoscopy or even laparotomy approaches are appropriate when damage to the bowel or bladder is detected or suspected. Although some surgeons may choose to manage focal dehiscence expectantly, it is generally considered prudent to proceed to surgical repair as this may be an area of further separation. Prior to cuff reclosure, all devitalized tissue should be removed using nonthermal approach such as scissors or scalpel. Closure should be accomplished using delayed absorbable suture with 1-cm tissue margins incorporating the vaginal mucosa and the pubocervical fascial ring.

Bowel evisceration is a very serious complication potentially leading to peritonitis, bowel injury with necrosis, and sepsis; prompt

surgical intervention is required. Repair is traditionally accomplished by laparotomy. A laparoscopic approach can be considered if the entire length of the bowel can be visually inspected and if the compromised segment of bowel can be resected and repaired successfully.

# Wound Complications

Postoperative wound complications such as infection occur less frequently with a laparoscopic approach owing to the smaller incision size. However, complications do occur specifically related to the use of trocars. These are related to trocar insertion specifically abdominal wall vasculature or nerve injury, intra-abdominal vascular or intestinal injury, or development of subsequent trocar site hernia (estimated to occur in <1% of cases). Trocars should be removed under visualization at the conclusion of the hysterectomy to watch for bleeding. The fascia should be closed in a layer separate from the skin closure if trocar sites are 10 mm or greater to avoid hernia formation. This can be accomplished using traditional suturing technique or by using a variety of commercially available products available for this purpose (Carter-Thomason device, Endoclose device, etc.). See Chapter 9 for additional discussion of trocar site closure.

# Urologic Injury

Gynecologic surgery, specifically hysterectomy, is the most common cause of iatrogenic urinary tract injury. A common risk factor for bladder injury is a history of prior cesarean section, pelvic adhesive disease, or endometriosis involving the bladder. However, >90% of ureteral injuries during laparoscopic hysterectomy can be attributed to thermal injury related to division of the cardinal ligament. A 2014 systematic review reported urinary tract injuries in 0.73% of total laparoscopic hysterectomies, with bladder injuries occurring slightly more frequently than ureteral injuries (0.6% vs 0.4%). Seventy-five percent of bladder injuries identified at the time of posthysterectomy cystoscopy were unsuspected. When cystoscopy is performed

immediately after hysterectomy, 89% of ureteral and 95% of bladder injuries are detected intraoperatively. Conversely, in the absence of cystoscopy, intraoperative detection drops to 43% of bladder and only 7% of ureteral injuries.

Postoperative morbidity is not increased when bladder injuries are recognized and repaired at the time of surgery. Intraoperative identification will avoid additional surgery and loss of renal function. The role of routine cystoscopy after hysterectomy continues to be debated, but fiscal analysis suggests that intraoperative cystoscopy becomes cost-effective when the injury rate exceeds 2%.

# CONCLUSION

The minimally invasive hysterectomy, regardless of vaginal or laparoscopic approach, offers many advantages to the patient. Laparoscopy provides superior exposure to the adnexa and upper abdomen and avoids a large abdominal wall incision, thus reducing the associated risk of infection, postoperative pain, and hernia. The advent of robotics technology applied to laparoscopic hysterectomy has facilitated the adoption of laparoscopic hysterectomy by many gynecologists previously hesitant to perform this procedure as it overcomes many of the challenges of traditional laparoscopy.

## KEY POINTS

- The choice of access for and type of hysterectomy should be based on the patient's anatomy and pathology. Supracervical hysterectomy should not be performed because of the surgeon's lack of comfort with removing the cervix. Instead, assistance from more skilled surgeons should be sought.
- The patient should be counseled thoroughly regarding anticipated outcomes, potential complications, preoperative preparation, and postoperative care. Risks and benefits of using energy-based instruments and morcellators should be included in the informed consent process. The surgeon should discuss

alternatives for tissue removal, including vaginal morcellation or laparotomy.

- Preoperative optimization of comorbidities, especially cardiovascular disorders, should be coordinated with the anesthesia team to minimize medical complications.
- An appropriate uterine manipulator and vaginal fornix delineator should be used for TLH and RA-TLH to improve procedural ergonomics and decrease complications.
- Ureters, bladder, and other anatomic landmarks should be clearly identified. Vessels should be isolated and skeletonized before coagulation.
- The surgeon should understand the electrosurgical and mechanical characteristics of energy-based instruments and apply those principles to minimize undesired thermal tissue effects.
- The robotic approach results in lower estimated blood loss, shorter length of stay, improved quality of life in the postoperative period, and fewer complications when compared with the abdominal approach. Other advantages include improved surgeon ergonomics, visualization, elimination of tremor, instrument range of motion, and a rapid learning curve.
- The colpotomy incision and amputation of the uterus are the most critical steps in performing TLH or RA-TLH with respect to potential urinary tract injury.
- Steps that can be taken during cuff closure to mitigate dehiscence include minimizing application of thermal energy during colpotomy and incorporating adequate healthy tissue in the suture line.

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# SECTION V

# Gynecologic Oncology


## 25 Surgery for Preinvasive Disease of the Cervix
Leslie H. Clark

## 26 Surgery for Preinvasive and Invasive Disease of the Vulva and Vagina
Ryan J. Spencer and David M. Kushner

## 27 Surgery for Uterine Cancer
Edward Tanner

## 28 Surgery for Cervical Cancer
Nadeem R. Abu-Rustum and Vance A. Broach

## 29 Surgery for Ovarian Cancer
Ritu Salani and Mae Zakhour

# CHAPTER 25

# SURGERY FOR PREINVASIVE DISEASE OF THE CERVIX

Leslie H. Clark

**Ablative Procedures**
Cryotherapy
Thermal Ablation
Carbon Dioxide Laser Therapy
**Excisional Procedures**
Cold Knife Conization
Loop Electrosurgical Excision Procedure
Postoperative Management
**Comparison of Methods**
**Complications**
**Dysplasia in Pregnancy**
**Information for Patients**

Cervical cancer screening has led to the increased identification and treatment of preinvasive cervical lesions. This in turn has led to a worldwide reduction in cervical cancer. Screening guidelines continue to evolve, but the importance of screening remains as persistent dysplasia, or human papillomavirus infection is associated with the development of cervical cancer. The treatment of dysplasia

with ablative or excisional procedures is key to cervical cancer prevention.

The choice of treatment approach should be made based on lesion factors (location, size, and suspicion for underlying malignancy) as well as patient factors (age, parity, and fertility desires) and cost. Finally, as with any procedure, physician preference, practice setting, and skill should be taken into consideration.

# ABLATIVE PROCEDURES

Ablative procedures for the treatment of cervical dysplasia include cryotherapy, laser ablation, and thermal ablation. These procedures treat dysplasia by tissue destruction. The potential benefits of an ablative approach include ease of technique, reduced operative risk, lower cost, and faster recovery. Thermal ablation has become the favored approach in low-resource settings due to low cost, shorter treatment time, and lack of need for refrigerant gas. However, when other procedures are available, ablative procedures should be avoided in patients with dysplasia on preprocedural endocervical curettage (suggesting a lesion that extends beyond the treated area) as well as patients with inadequate colposcopy because no pathology specimen is obtained. Ablative procedures should also not be performed in patients with biopsies discordant with cytology, suggesting inadequate sampling of the lesion on biopsy, and in patients with a suspected cervical cancer.

## Cryotherapy

Cryotherapy was introduced for the treatment of dysplasia in the 1960s. Due to limitations of ablative approaches and resultant lack of available tissue for evaluation, this procedure has been largely replaced by office excisional procedures in the United States. Cryotherapy utilizes nitrous oxide or carbon dioxide as a refrigerant to lower tissue temperatures below −50 °C. Nitrous oxide is considered the preferred refrigerant as it reaches colder temperatures than does carbon dioxide (−89 °C vs −78 °C), resulting

in a greater depth of tissue necrosis. Lowering the tissue temperature to −50 °C results in intracellular and extracellular crystallization of water and causes tissue necrosis. The target depth of tissue necrosis is 3.5 mm, which will result in treatment of 95% of intraepithelial lesions. There are some data to suggest that cryotherapy is less effective in women with HIV with success as low as 37% in HIV-positive women compared to 77%-93% effectiveness in HIV-negative women.

The procedure starts with the application of Lugol's or acetic acid to identify the transformation zone. A cryoprobe size is selected and then applied to cover the entire transformation zone. The refrigerant is applied directly to the ectocervix and transformation zone with use of a lubricant gel to enhance energy transfer. Steady state is reached between the probe and cervix in 3-5 minutes.

During the procedure, visible ice is seen ~5 mm past the probe. The area of tissue treated then gradually regresses and heals. Some prefer to perform a second freeze; however, the utility of a second freeze is unclear, and pathologic evaluation after one and two freeze procedures show noninferiority of a single freeze on the anterior cervical lip. A second freeze could be considered in posterior lesions as the depth of tissue damage may be increased with a second freeze posteriorly (**FIG. 25.1**).

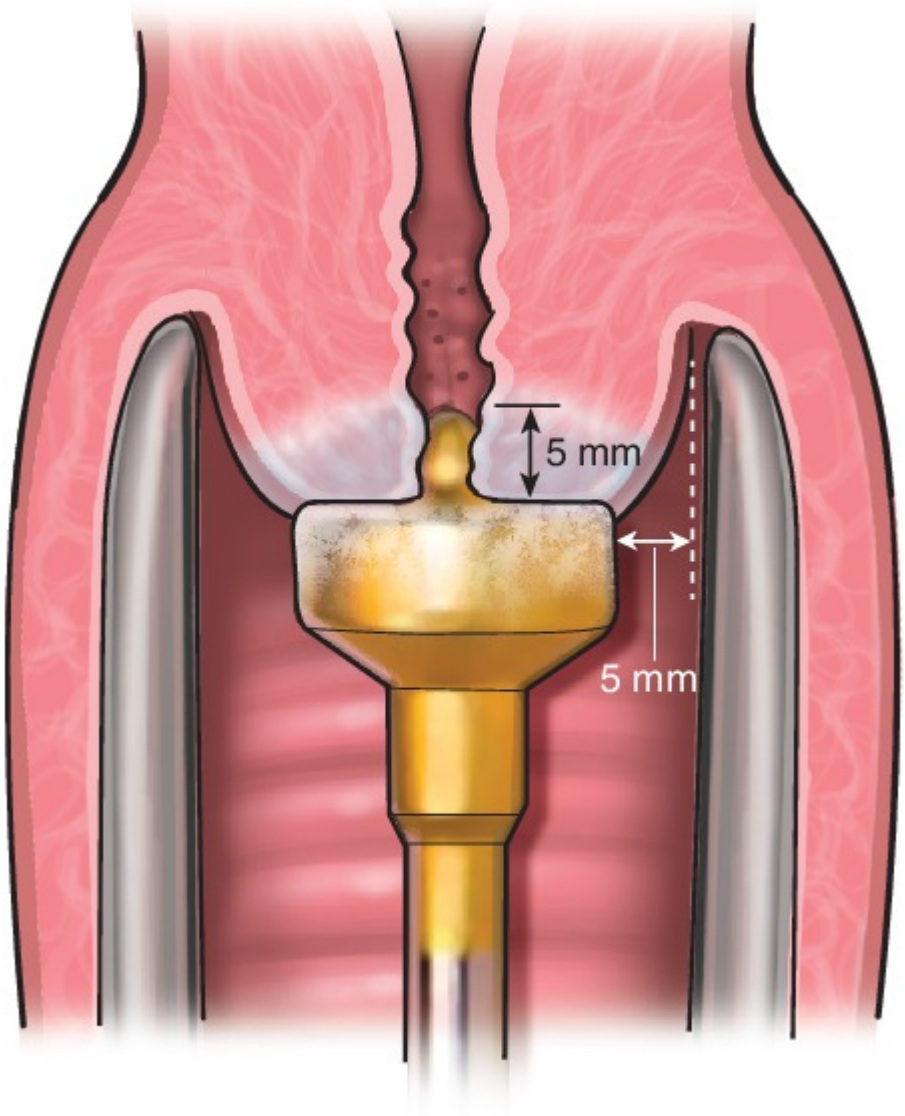


**FIGURE 25.1** Cryotherapy results in destruction of local tissue, and ice should be seen extending ~5 mm from the probe. The entire transformation zone should be covered.

The most common side effect of cryotherapy is minor crampling during the procedure and this is limited. Up to 20% of patients will report diffuse watery discharge. Light spotting can occur and is most commonly noted 12-15 days following the procedure. Pelvic rest is recommended for 2 weeks to minimize bleeding and infection. Long-

term complications include a 1%-4% risk of cervical stenosis. This procedure does not affect pregnancy outcomes. Major bleeding or infection occurs less frequently than with excisional procedures.

# Thermal Ablation

Cryotherapy requires sizable tanks of nitrous oxide to perform the freezing procedure, and the logistics of purchasing and transporting these tanks can be challenging. In response to these limitations, particularly in low-resource settings, handheld, battery-operated thermal probes (thermocoagulators) containing a shaft with heated tip have been designed for cervical thermal ablations with similar surgical and oncologic outcomes to cryotherapy. A variety of tips that vary in size and shape can be used to customize treatment of lesions. Similar to cryotherapy once the lesion and transformation zone are identified, the probe is applied directly to the cervix. The probe is then activated for a predetermined time and temperature setting, which allows for steady state and tissue temperatures to rise to 100 °C or more. Standard treatment cycles can range from 20 to 45 seconds. Multiple cycles can be used to ensure that the lesion is fully treated.

Similar to cryotherapy ablation, patients may experience cramping during the procedure, but most is mild and self-limited. Some providers prefer to perform a paracervical or intracervical injection of local anesthetic to minimize discomfort. Most patients experience watery discharge with up to 10% experiencing light bleeding or spotting (**FIGS. 25.2 and 25.3**).

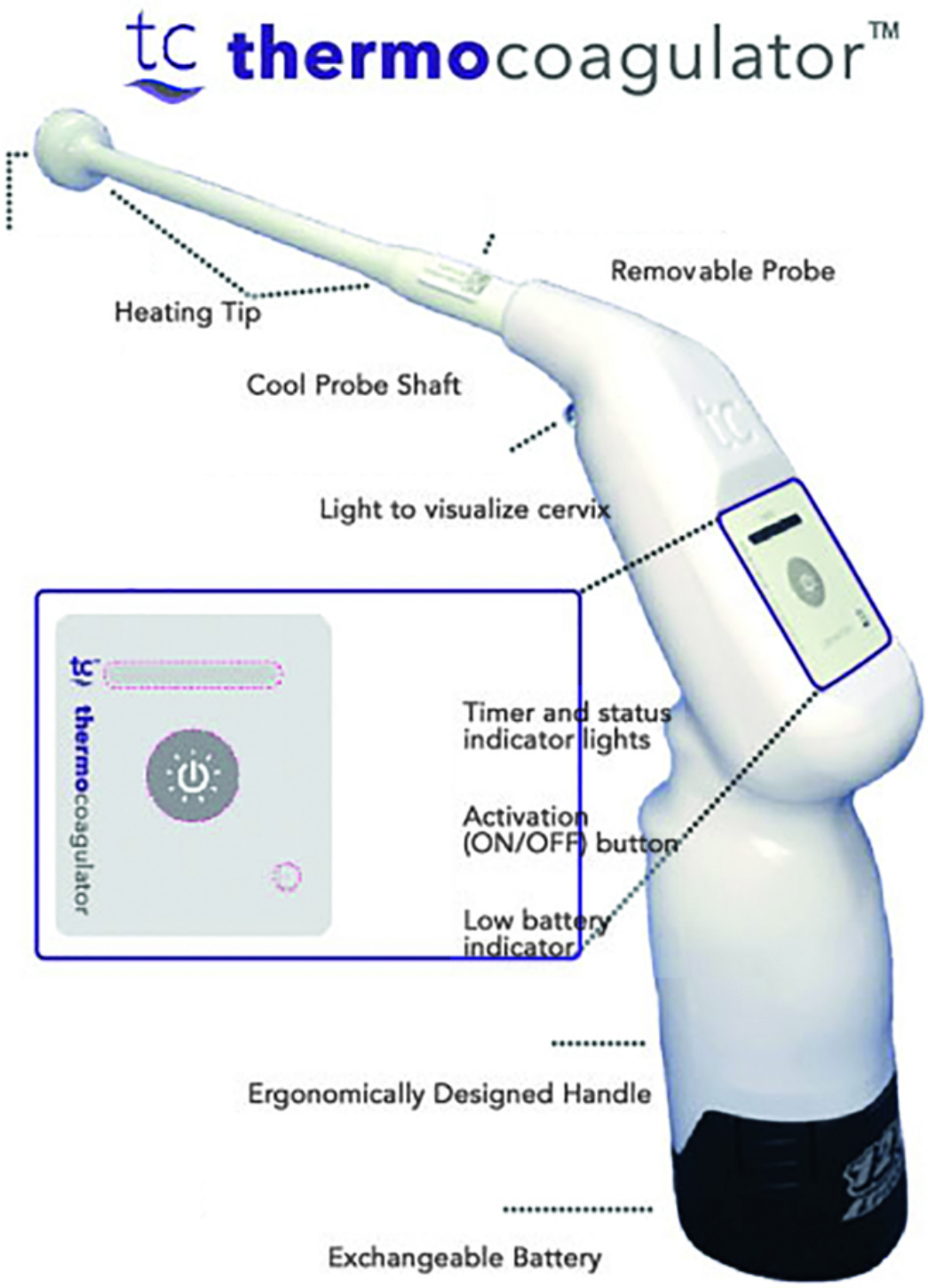


**FIGURE 25.2** Liger Thermocoagulator. (Courtesy of Liger Medical.)

**FIGURE 25.3** Thermocoagulator with handle, rechargeable lithium-ion 12v batteries (each battery will treat 30-50 patients), probes (there are three different configurations of probes available, 19 mm flat, 19 mm nipple, 16 mm flat), battery charger, and hard carrying case. (Courtesy of Liger Medical.)

## Carbon Dioxide Laser Therapy

Carbon dioxide ($CO_2$) laser therapy is an ablative technique using high-intensity collimated light beam that can be focused with high-power density. The laser energy causes flash boiling of cells and tissue vaporization. The benefits of $CO_2$ laser include targeted lesion therapy, ability to treat lesions that extend onto the vagina, rapid healing, and lower cervical stenosis rates than cryotherapy. The disadvantages of the $CO_2$ laser are the equipment acquisition expense, training required for use, and maintenance cost for the laser.

To perform $CO_2$ laser ablation, a matte speculum with smoke evacuator spigot is placed in the vagina and the cervix visualized. Nonreflective speculums prevent laser scatter. Smoke evacuation tubing is attached. The perineum is draped with wet towels to prevent fire as laser is absorbed by water. Flammable drapes such as paper drapes should be avoided. The cervix is injected with local anesthetic, such as 1% lidocaine with or without vasoconstrictive agent. The colposcope is used to magnify the cervix 3-10 times. The laser is then set to a density between 750 and 1250 $W/cm^2$ by adjusting the power input and spot size. Ablation of the lesion and transformation zone is then performed. The recommended depth of cervical ablation is 7 mm.

# EXCISIONAL PROCEDURES

Excisional procedures for treatment of dysplasia include cold knife conization (CKC), laser cone, and loop electrosurgical excision procedure (LEEP). Unlike ablations, these procedures allow removal of specimen, which can be sent for pathologic diagnosis. In addition to this benefit, these techniques allow for assessment of margin status. LEEP has largely replaced laser conization as it is less technically difficult and safer to perform, is less expensive, and can be performed in an outpatient setting. Laser conization is rarely performed currently and this procedure is not reviewed.

# Cold Knife Conization

Termed cold to distinguish from use of hot cautery, a cold knife conization (CKC) refers to circumferential excision of the distal cervix using a scalpel. The benefits of this procedure are that lesions extending into the endocervical canal can be excised, and there is no cautery artifact at the margin allowing for improved pathologic assessment of margin status. This procedure can be tailored to cervical shape or lesion configuration. A flattened excision is planned for an ectocervical lesion and more cylindrical excision for endocervical lesions. Cold knife conization is also preferred when invasive cancer is suspected for these reasons. Compared to LEEP procedures, cold knife conization is more expensive as it is performed in the operating room under anesthesia. There is also a higher risk of bleeding.

The procedure begins with an examination under anesthesia followed by vaginal prep. A weighted speculum is placed in the vagina, and a Deaver retractor is used to retract anteriorly to elevate the bladder and expose the cervix. A local anesthetic such as 1% lidocaine with epinephrine (1:100 000) can be injected directly into the cervical face. Use of epinephrine reduces intraoperative bleeding, which can obscure visualization. Alternatively, dilute vasopressin can be used. Typically, 20 IU of vasopressin is diluted in 50 mL of saline, and 10-15 mL is injected into the cervical stroma. Some may prefer to use plain lidocaine witihout additives as to not mask intraoperative bleeding. Approximately 10-20 mL of lidocaine is injected, and patient weight should be taken into consideration before using larger doses. Next, stay sutures are placed at 3 and 9 o'clock positions to assist with cervical manipulation. It is also believed that these sutures can ligate cervical branches of the uterine artery and reduce intraoperative and postoperative bleeding. During placement of these sutures, it is important to not travel too deep or lateral so as to not to trap the ureter and cause ureteral injury. Lugol solution is applied to the cervix to visualize the squamocolumnar junction and plan excision.

A No. 11 blade scalpel is used to incise the cervical face circumferentially. Starting on the posterior cervix, at "6 o'clock

position," is a good strategy to improve visualization by avoiding bleeding from the 12 o'clock anterior cervix. If a tenaculum is placed on the cervix to assist with cervical or specimen manipulation, it should be placed outside of the intended line of excision. Alternatively, a stitch can be placed at 12 o'clock position and used to elevated the specimen out of the cone bed during excision, as well as remain in place for pathologic orientation. The circumferential incision is made in the stroma, and the tissue is grasped with Allis clamps anteriorly and posteriorly to expose the margins of the cone specimen, which is excised circumferentially with the scalpel or scissors to complete the conization. Following conization, an endocervical curetting (ECC) should be performed as this has been shown to predict residual dysplasia. In patients with adenocarcinoma *in situ* who desire fertility, ECC was found to have a 100% positive predictive value for residual dysplasia and 94% negative predictive value compared to cone margins with a 47% positive predictive value and 57% negative predictive value. An ECC showing no residual dysplasia is superior to margin status in predicting residual adenocarcinoma *in situ*.

Following specimen removal, the specimen is tagged at the 12 o'clock position for pathologic orientation if a suture has not already been placed. The cone bed can then be cauterized for hemostasis. In some cases, this may be the only maneuver needed to obtain hemostasis. Additional options for obtaining hemostasis in the cone bed include placing sutures, use of topical Monsel solution, direct pressure, or use of absorbable hemostatic agents such as absorbable gelatin powder (brand name Gelfoam). Suture techniques to consider if these first maneuvers are not successful include placement of a running locking closure along excised edges or Sturmdorf sutures. To place a Sturmdorf, a mattress suture is placed both anteriorly and posteriorly to pull the lateral cervical mucosa over the cone bed (**FIG. 25.4**; **BOX 25.1**).

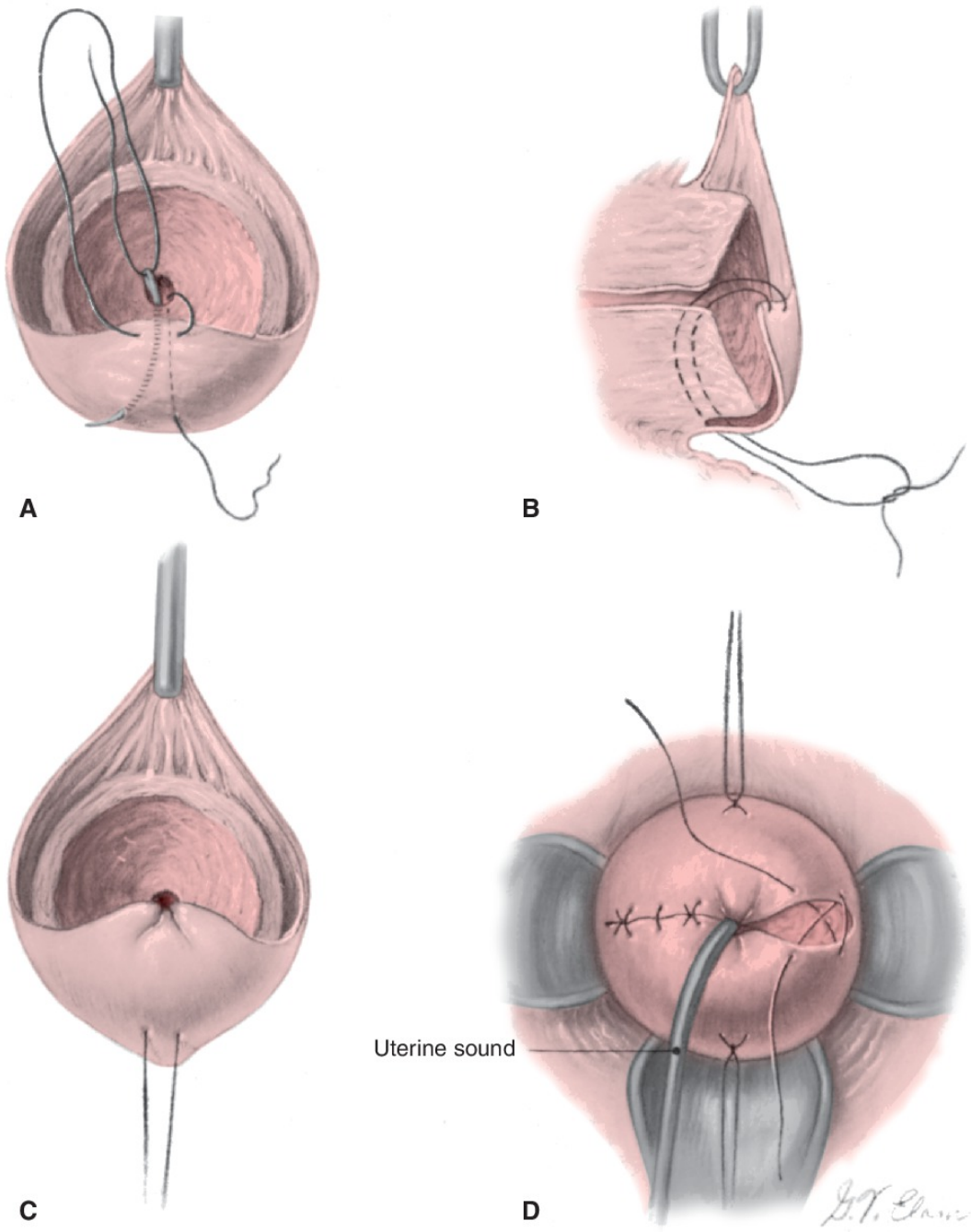


**FIGURE 25.4** **A.** To place Sturmdorf suture, a mattress suture is placed as shown, from edge of cervical mucosa to internal canal. **B.** Method of action of suture in drawing the flap into the canal. **C.** The lower flap has been

pulled into position. **D.** Anterior and posterior flaps have been drawn into the canal. Lateral mucosa wounds are being sutured.

## BOX 25.1 STEPS OF PROCEDURE FOR CKC

- Identify squamocolumnar junction using Lugol solution.
- Perform vaginal prep.
- Place retractors for exposure.
- Inject topical anesthetic (with or without vasoconstrictive additives).
- Place stay sutures at 3 and 9 o'clock positions. Can use absorbable braided suture for stay sutures.
- Incise circumferentially with No. 11 blade, starting at 6 o'clock position.
- Place traction on specimen and excise cone at base using scalpel or scissors.
- Perform ECC after excision of cone specimen.
- Tag specimen for pathology orientation.
- Obtain hemostasis of cone bed with cautery.

# Loop Electrosurgical Excision Procedure

While the CKC was the standard of care for excision of the cervix for a number of decades, Prendeville introduced the large loop excision of the transformation zoom (AKA LEEP) in the 1990s, which has since become the procedure of choice for treatment of dysplasia. The benefit of LEEP was the ability to perform the procedure in the outpatient setting under local anesthesia with significant reduction in

cost. Another benefit is the excellent hemostasis provided by performing the excision with the electrosurgical wire. It is also easy to perform, teach, and learn. Not all patients are appropriate candidates for LEEP, however. Cervical anatomy should be compatible with use of the preset loop sizes. Further, significant patient anxiety may preclude performing the procedure in the office setting and necessitate that the procedure be performed in the operating room. Because of the ease of performing the LEEP technique, some providers have moved to using a “see-and-treat” strategy proceeding straight from high-grade pap to LEEP without undergoing diagnostic biopsies. This is an important strategy in clinics with high no-show rates or low resources such as those in low-income countries.

Prior to the procedure, loop selection and procedure setup are critical to the success of the procedure. The proper loop size should be chosen to excise the entire transformation zone. Loops are available ranging from 15 to 25 mm in electrode diameter (width). Size should be chosen based on the size of the cervix, lesion, and extent of transformation zone (**FIG. 25.5**). Using a loop that is too large can increase risk of injury to the vaginal walls, rectum, and bladder. Removing more cervical tissue than is clinically necessary may lead to future obstetrical complications. Use of large loops is most appropriate for diagnostic evaluation of adenocarcinoma *in situ* or suspected carcinoma or in patients who have completed childbearing.

**FIGURE 25.5** The size of the LEEP electrode should be chosen based on the transformation zone size and fertility desires. A large superficial electrode can be used for a wide transformation zone in a patient desiring fertility (*bottom*). A deeper electrode will target endocervical glands (*top*). A smaller, narrow electrode (not pictured) is also available for use in a small, narrow cervix or vagina, such as those who are postmenopausal. (Courtesy of CooperSurgical, Inc.)

Medications to assemble prior to the procedure include acetic acid (5%), Lugol solution for visualization of the transformation zone, local anesthetic with epinephrine, Monsel solution to apply to the cervix after treatment to address bleeding, and povidone-iodine or other antiseptic solution for cervical prep (**TABLE 25.1**). There is no role for buffering the local anesthetic with bicarbonate, as a randomized trial showed no benefit to this practice. The electrosurgical generator should be set to appropriate power settings based on the loop wire size and manufacturer's guidelines. Finally, a 12-in needle holder and a 12-in pickup forceps should be available in case suturing is required, and 0-gauge delayed-absorbable suture (such as Vicryl) on a 1-in curved, taper-point needle, and vaginal packing should be available in the event of that greater than expected bleeding occurs. An example of LEEP setup is show in **FIGURE 25.6**.

## TABLE 25.1 Equipment for Loop Electrical Excision Procedure

| | |
|---|---|
| Medications | • Monsel solution<br>• Betadine or chlorhexidine<br>• Lugol solution and acetic acid<br>• Local anesthetic such as 1% lidocaine with or without epinephrine or dilute vasopressin |
| Supplies | • Large cotton swabs<br>• Insulated speculum with tubing for smoke evacuation<br>• Single-tooth tenaculum<br>• Spinal needle for cervical block<br>• Multiple loops<br>• Electrocautery |

**FIGURE 25.6** Example of LEEP tray including tenaculum, pickups, acetic acid, ring forceps,

Lugol solution, Betadine, Monsel solution, large and small cotton swabs, gauze. Sodium bicarbonate is included in this tray to buffer the anesthetic, but studies have not shown this to be beneficial. (Courtesy of Dr. Lisa Rahangdale.)

Once the setup is complete, the procedure begins with insertion of an insulated speculum. Insulation is important as it protects the vagina from epithelial injury. The speculum should be opened to maximally tolerated amountto expand vaginal exposure. Povidone-iodine is used to clean the cervix. A tenaculum or ring forceps can be applied to the cervix to assist with cervical manipulation during the procedure but should be placed in a location that will not interfere with loop application during excision. Acetic acid or Lugol solution is applied to visualize the transformation zone. Local anesthetic (with epinephrine) is injected into the cervix until blanching of tissue is noted; this is not placed as a paracervical block. If there is uncertainty regarding the angle and orientation of the endocervical canal, a sound can be inserted into the os to confirm its direction.

Loop size is chosen based on anatomy, transformation zone, and lesion size. The loop electrode should be activated prior to touching the tissue. The electrode is then gently passed through the tissue while maintaining the current until the pass is complete. Loss of current during the procedure stops the cutting wave, and reinitiation of the current from the opposite direction can result in bleeding at the junction of where the two passes meet. Similarly, reactivation of the current can result in increased thermal artifact. The loop can either be passed from side to side or from top to bottom. Some favor starting at the area of most concern based on the preoperative biopsy or visualized lesion to ensure the best pathologic assessment at this location. Starting the excision from top to bottom can result in the specimen falling into operative field and obscuring the view.

The depth of excision should be >5 mm, and ideally at least 7-8 mm, to allow for excision of the underlying endocervical glands. This depth has been shown to remove most preinvasive lesions without adding undue risk for complications. Additionally, the majority of dysplasia is found at the squamocolumnar junction or transformation zone, so removing this area intact for pathologic evaluation is important. Multiple passes may be required to remove the entire transformation zone, but this should be discouraged as submitting multiple portions can impact pathologic orientation and diagnosis. it is best to obtain a full specimen with one pass if possible. A “top hat” is often performed after excision of the ectocervix to remove residual squamous epithelium or endocervix but should not be routinely performed as deep excisions are associated with increased risk of adverse obstetric outcomes. However, this additional excision is particularly important in the setting of inadequate colposcopy due to nonvisualization of the entire transformation zone or if preprocedural ECCs showed dysplasia or malignancy deeper in the endocervical canal. The top hat is performed using a smaller loop, either 10 × 10 mm or 10 × 15 mm wire loops. This excision should extend ~5 mm lateral to the canal to allow for incorporation of the gland crypts.

Finally, consideration should be given to performing an endocervical curettage after LEEP to assess for higher lesions or residual dysplasia (**FIG. 25.7A and B**; **BOX 25.2**).

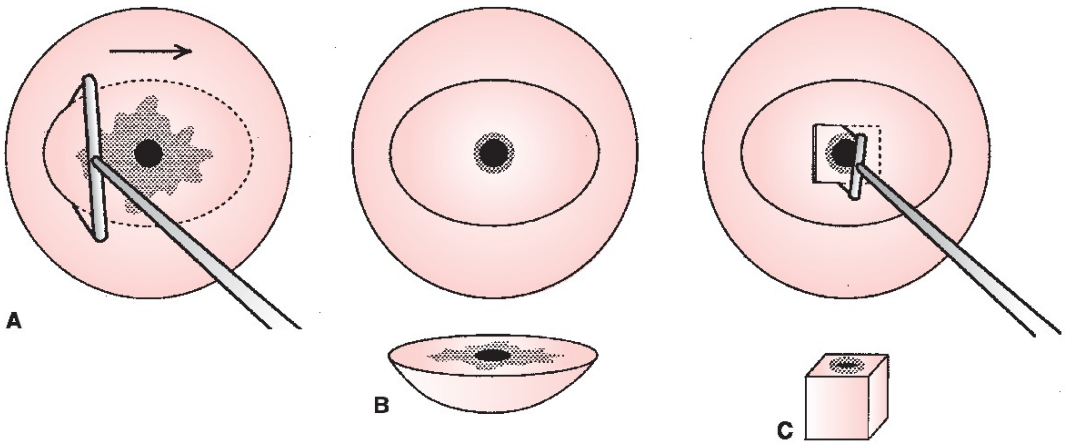

**FIGURE 25.7** Diagram of approach to loop excision of small lesion, which can be removed by a single pass **(A)** of the 2 cm × 8 mm loop. **B.** Note the shallow dish configuration of the removed cervical tissue. If squamous epithelium remains in the canal, it can be removed with a second pass of a smaller loop, also known as a top hat **(C)**.

## BOX 25.2 STEPS OF PROCEDURE FOR LEEP

- Select LEEP electrode size.
- Identify squamocolumnar junction using Lugol solution or acetic acid.
- Perform vaginal prep.
- Place matte speculum and attach smoke evacuator.
- Inject local anesthetic.
- Connect cautery to electrode and activate.
- Excise specimen with LEEP electrode from side to side or top to bottom.
- Tag specimen for pathology orientation.
- Perform “top hat” if indicated.
- Fulgurate LEEP bed with the 5-mm electrocautery ball.
- Can obtain hemostasis of excision bed with additional cautery or apply Monsel solution.

Hemostasis is obtained following excision by fulgurating the LEEP bed with the 5-mm electrocautery ball. A 3-mm ball is also available

for top hat bed fulguration. Large cotton swabs can be used to collect blood and maximize cautery application to the bed. Monsel solution can be applied, or suture placed if needed for control of bleeding.

One additional consideration in performing LEEP procedures is the hypothetical risk of exposure to human papillomavirus via surgical smoke inhalation. Effective surgical smoke evacuation and ventialation should be planned and use of N95 face masks should be considered.

## Postoperative Management

General postoperative instructions following an excisional procedure include pelvic rest, instructions for what constitutes normal and abnormal amounts of bleeding, and instructions to monitor for fever. All patients are advised to watch for bleeding heavier than one pad per hour or signs of anemia. Most bleeding will occur within the first 24 hours of the procedure; however, increased bleeding is also seen between 10 and 21 days postoperatively. The bleeding risk is higher after CKC than LEEP, and up to 5%-10% of CKCs are associated with a bleeding complication. A patient experiencing bleeding after the procedure should be evaluated by a provider if there is significant passage of clots or use of more than one pad per hour. Fever precautions should also be given, although cervical or uterine infection following excision is uncommon. Finally, appropriate follow-up should be arranged with both postoperative visit and ongoing evaluation for persistent or recurrent dysplasia.

# COMPARISON OF METHODS

The key difference between ablative and excisional procedures is the lack of obtaining a pathologic specimen after performing an ablative procedure. Prior to the introduction of LEEP, ablative procedures represented a less expensive outpatient alternative to cold knife conization and thus were widely performed. However, with the widespread availability of outpatient LEEP, this is currently the treatment of choice for cervical dysplasia. LEEP procedures have a

similar cost to ablative procedures but allow for definitive pathologic diagnosis and evaluation of margin status.

When comparing LEEP to CKC, the key benefits of LEEP are the ability to complete the procedure in the outpatient setting, and this procedure is less expensive to perform. A recent meta-analysis showed similar outcomes with use of LEEP and CKC in the treatment of adenocarcinoma *in situ* in women who desired future fertility, although some still prefer the depth obtained with CKC for this disease. CKC allows for a more tailored excision with no cautery artifact at the margin on pathologic evaluation. One key factor that distinguishes LEEP from CKC aside from cost considerations is obstetric outcomes. LEEP instead of CKC should be considered in young women who desire future fertility given the lower rates of preterm birth associated with this LEEP (2-fold increased risk with LEEP vs 2.7-fold increased risk with CKC).

# COMPLICATIONS

The most common short-term complications of an excisional procedure are bleeding, cramping, and infection. Other potential risks include uterine perforation, infection, and damage to the rectum or bladder.

Intraoperative bleeding is generally minimal and can be managed as previously discussed. Most commonly, a combination of electrocautery, Monsel solution, and placement of suture should adequately control bleeding. Postoperative bleeding is most common in the first 24 hours with a second window of increased bleeding risk occurring from 10 to 21 days postoperatively when the eschar (sloughing tissue) falls off and suture involutes. The overall risk of bleeding is ~5%.

Postoperative infection is rare and, when it occurs, likely represents a flare of a subclinical infection that was present prior to excision. Studies report 1% to 14% infection rates following LEEP to up to 36% with CKC. An infection can present in the form of cervicitis, endometritis, parametritis, or salpingitis. If clinical infection is encountered, antibiotics covering polymicrobial infection should be

utilized. There are no data to support the routine use of prophylactic antibiotics with either excisional or ablative cervical procedures.

Other rare complications such as uterine perforation and bladder or rectal injury can largely be avoided with appropriate surgical technique. To reduce the risk of uterine perforation, examination under anesthesia and evaluation of uterine lie should be planned. Placement of a tenaculum or stay sutures to place the uterus into the midposition during excision should appropriately orient the cervix during the procedure. Similarly, the risk of rectal or bladder injury can be minimized with optimal visualization and careful identification of the cervicovaginal junction both anteriorly and posteriorly.

One of the late complications of cervical excisional procedure is cervical stenosis. Cervical stenosis occurs in 3% of patients after CKC and 1% of patients after LEEP. It is more common in postmenopausal women. It may present with pelvic pain from fluid retention in the uterus and require cervical dilation for resolution **TABLE 25.2**.

## TABLE 25.2
## Risks of Excision Procedures

| |
|---|
| Bleeding |
| Infection |
| Cramping |
| Uterine perforation |
| Damage to the rectum and bladder |
| Cervical stenosis |

Finally, given that most dysplasia occurs in women of childbearing age, one important consideration is the risk for preterm birth related to cervical excision. Women with dysplasia in general are at a higher risk for preterm birth. Undergoing an excisional procedure increases

the risk of preterm birth 2-fold when an LEEP is performed and 2.7-fold when CKC is performed. Even undergoing an ablative procedure increases the risk for preterm birth by 1.5-fold compared to no treatment. Fortunately, most preterm birth occurs between 34 and 36 weeks' gestation, and the overall risk of preterm birth remains low. The relative risk of preterm birth is increased at all gestational ages following these procedures, and patients should be appropriately counseled. The key risk factors for preterm birth are the depth of excision and number of excisions. A procedure should be tailored to the patient and lesion to remove as much tissue as needed with a single procedure. The majority of preinvasive lesions are <5 mm in depth, suggesting that a depth of 6-7 mm would remove majority of lesions without undue increased obstetric risk (**TABLE 25.3**).

## TABLE 25.3
## Obstetric Outcomes After Excisional Procedure

| Procedure | Relative risk of preterm birth <37 weeks (confidence interval) |
|---|---|
| No procedure | — |
| LEEP | 1.74 (1.45-2.10) |
| CKC | 2.89 (2.08-4.03) |
| Two LEEP | 2.81 (2.33-3.39) |
| Two excision NOS | 5.48 (2.68-11.24) |

From Kyrgiou M, Athanasiou A, Paraskevaidi M, et al. Adverse obstetric outcomes after local treatment for cervical preinvasive and early invasive disease according to cone depth: systematic review and meta-analysis. *BMJ*. 2016;354:i3633. http://creativecommons.org/licenses/by/3.0/

Up to 91%-98% of dysplasia will be treated successfully with the above procedures and will not require further therapy. Positive margins for residual disease are the most important predictor of

persistent or recurrent dysplasia. LEEP margins are less predictive than cone margins, particularly if more than one pass is needed. Patients with postivie margins should undergo repeat Pap smear and ECC in 6 months. In women who have completed childbearing and for whom re-excision is not possible, hysterectomy can be considered. Immediate re-excision is only indicated if invasive cancer is suspected but not for positive margins.

Patients who have microinvasive cancer (<3-mm invasion) or adenocarcinoma *in situ* and have completed childbearing should undergo hysterectomy after 6 weeks of postoperative healing. Additionally, those with persistent dysplasia and no residual cervix for re-excision are candidates for hysterectomy if childbearing is complete.

# DYSPLASIA IN PREGNANCY

In general, cervical excision procedures are not performed on pregnant women due to the significant vascularity of the gravid cervix and risk of stimulating uterine contractions. Excisional procedure of the cervix should be deferred until 6 weeks postpartum when uterine involution has occurred. If a lesion is concerning for invasive cancer in pregnancy, this should prompt a biopsy to confirm the diagnosis, and treatment can be delayed until after delivery. It is appropriate to deliver such a patient once fetal lung maturity is confirmed.

# INFORMATION FOR PATIENTS

- **Preoperative instructions**
  - Discontinuation of therapeutic anticoagulation
  - NPO guidelines based on the use of anesthesia
- **Postoperative instructions**
  - Pelvic rest 4 weeks
  - Bleeding and fever precautions
  - Follow-up—post-op visit and dysplasia surveillance

# KEY POINTS

- Identification and treatment of preinvasive lesions has reduced the incidence of cervical cancer.
- Excision and ablation have similar cure rates, but excision procedures are preferred in high-resource settings to allow for pathologic evaluation and margin status.
- Excisional procedures are associated with increased risk of preterm birth related to depth of excision and number of prior excisions; however, all patients with dysplasia have increased risk of preterm birth.
- LEEP procedures are cost-effective as they are performed in an outpatient clinic, can be both diagnostic and therapeutic, and are recommended for the treatment of lesions CIN2/CIN3.
- LEEP should begin with activation of the electrode prior to tissue contact to reduce bleeding risk.
- Bleeding risk with LEEP is lower than CKC.
- CKC should be chosen when glandular or malignant lesions are suspected, and pathologic orientation and uncauterized margin status are important to know for management purposes.

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# CHAPTER 26

# SURGERY FOR PREINVASIVE AND INVASIVE DISEASE OF THE VULVA AND VAGINA

Ryan J. Spencer and David M. Kushner

**Surgery for Preinvasive Disease of the Vagina**
Vaginal Biopsy
$CO_2$ Laser Vaporization
Vaginectomy
**Surgery for Vaginal Cancer**
**Surgery for Preinvasive Disease of the Vulva**
Diagnostic Vulvar Biopsy
$CO_2$ Laser Vaporization
Simple Vulvectomy
**Surgery for Vulvar Cancer**
Radical Vulvectomy
Urethral Resection
Management of Vulvar Cancer With Perianal Involvement
Inguinofemoral Lymphadenectomy
Inguinofemoral Sentinel Lymph Node Mapping
**Ultraradical Surgery for Vulvar Cancer**

**Surgery for Less Common Vulvar Malignancies**

Paget Disease of the Vulva

Malignant Melanoma of the Vulva

Bartholin Gland Carcinoma

Basal Cell Carcinoma

Sarcomas

Verrucous Carcinoma

**Reconstruction**

Skin Grafts

Flaps for Reconstruction

Vulvar and vaginal cancers are the least common gynecologic cancers. Vulvar cancer is most often a postmenopausal disease, and the average age of diagnosis is 68 years. It usually presents at an early stage, and the most common histology is squamous carcinoma. Like its cervical cancer counterpart, human papillomavirus (HPV) infection plays a role in the development of most vulvar cancers: HPV 16 is the most common subtype followed by HPV 33 and 18. Invasive vulvar carcinoma has two recognized precursor lesions: (1) high-grade vulvar intraepithelial neoplasia (usual type VIN; also termed vulvar high-grade squamous intraepithelial lesion), which is commonly associated with HPV infection, and (2) differentiated vulvar intraepithelial neoplasia (dVIN), which is not associated with HPV but can be associated with vulvar dermatoses (eg, lichen sclerosis). Either VIN subtype is a direct precursor of vulvar squamous cell cancer. The risk of subsequent development of vulvar carcinoma ranges from 2% to 15%. Low-grade squamous intraepithelial lesions (vulvar LSIL or VIN1) are felt to be overall benign and not a precursor of vulvar cancer (**TABLE 26.1**).

## TABLE 26.1
## Histologic Subtypes of Primary Vulvar Cancers

| HISTOLOGY | PERCENTAGE |
|---|---|
| Squamous cell carcinoma | 81% |
| Basal cell carcinoma | 8% |
| Melanoma | 6% |
| Other histologies | 5% |

Adapted from Schuurman MS, van den Eiden LC, Massuger LF, et al. Trends in incidence and survival of Dutch women with vulvar squamous cell cancer. *Eur J Cancer*. 2013;49:3872-3880.

Primary vaginal cancer is a rare gynecologic cancer accounting for only 3% of female-specific cancers in the United States. Most vaginal cancers are metastatic from other gynecologic organs such as the endometrium and cervix. For primary vaginal cancers, squamous carcinoma is the most common histology, and the mean age of diagnosis is around 60 years. The presenting symptom is usually vaginal bleeding. *In utero* DES exposure is related to the development of vaginal clear cell adenocarcinoma but is increasingly uncommon after the 1971 FDA advisory to discontinue its use in pregnancy. High-grade vaginal intraepithelial neoplasia (VAIN II/III) is the direct precursor of primary squamous cell vaginal carcinoma, and HPV 16 is the most frequent HPV subtype encountered. External genitalia anatomy is shown in **FIGURE 26.1**. FIGO 2009 Staging of Vaginal Cancer and FIGO 2021 Staging of Vulvar Cancer are shown in **TABLES 26.2 and 26.3**, respectively.

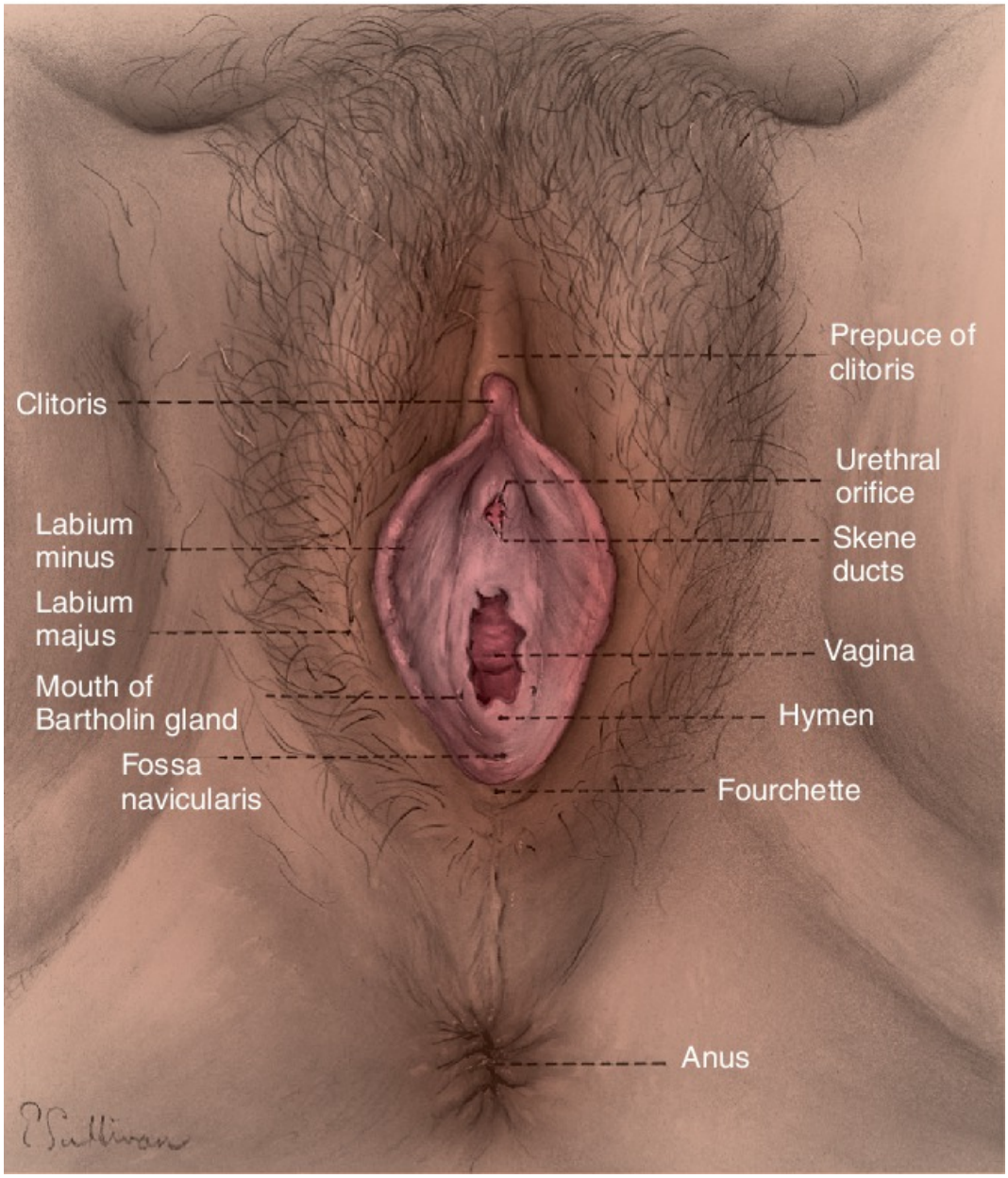


**FIGURE 26.1** External genitalia anatomy.

## TABLE 26.2
## 2009 FIGO Staging for Vaginal Carcinoma

| 2009 FIGO Staging for Vaginal Carcinoma | |
|---|---|
| I | The cancer is only in the vagina and is no larger than 2.0 cm (4/5 in) (T1a)<br>It has not spread to nearby lymph nodes (N0) or to distant sites (M0) |
| I | The cancer is only in the vagina and is larger than 2.0 cm (4/5 in) (T1b)<br>It has not spread to nearby lymph nodes (N0) or to distant sites (M0) |
| II | The cancer has grown through the vaginal wall but not as far as the pelvic wall and is no larger than 2.0 cm (4/5 in) (T2a)<br>It has not spread to nearby lymph nodes (N0) or to distant sites (M0) |
| II | The cancer has grown through the vaginal wall but not as far as the pelvic wall and is larger than 2.0 cm (4/5 in) (T2b)<br>It has not spread to nearby lymph nodes (N0) or to distant sites (M0) |
| III | The cancer can be any size and might be growing into the pelvic wall and/or growing into the lower one-third of the vagina and/or has blocked the flow of urine (hydronephrosis), which is causing kidney problems (T1-T3)<br>It has also spread to nearby lymph nodes in the pelvis or groin (inguinal) area (N1) but not distant sites (M0) |
| III | The cancer is growing into the pelvic wall and/or growing into the lower one-third of the vagina and/or has blocked the flow of urine (hydronephrosis), which is causing kidney problems (T3)<br>It has not spread to nearby lymph nodes (N0) or to distant sites (M0) |
| IVA | The cancer is growing into the bladder or rectum or is growing out of the pelvis (T4)It might or might not have spread to lymph nodes in the pelvis or groin (inguinal) area (Any N).<br>It has not spread to distant sites (M0) |
| IVB | The cancer has spread to distant organs such as the lungs or bones (M1). It can be any size and might or might not have grown into nearby structures or organs (Any T)<br>It might or might not have spread to nearby lymph nodes (Any N) |

Reprinted with permission from Adams TS, Rogers LJ, Cuello MA. Cancer of the vagina: 2021 update. *Int J Gynecol Obstet*. 2021;155(Suppl. 1):19-27.

## TABLE 26.3
## 2021 FIGO Staging for Vulvar Carcinoma

| STAGE | DESCRIPTION |
|---|---|
| I | Tumor confined to the vulva |
| IA | Tumor size ≤2 cm and stromal invasion ≤1 mm[a] |
| IB | Tumor size >2 cm or stromal invasion >1 mm[a] |
| II | Tumor of any size with extension to lower one-third of the urethra, lower one-third of the vagina, lower one-third of the anus with negative nodes |
| III | Tumor of any size with extension to upper part of the adjacent perineal structures or with any number of nonfixed, nonulcerated lymph node |
| IIIA | Tumor of any size with disease extension to upper two-thirds of the urethra, upper two-thirds of the vagina, bladder mucosa, or regional lymph node metastases ≤5 mm |
| IIIB | Regional[b] lymph node metastases >5 mm |
| IIIC | Regional[b] lymph node metastases with extracapsular spread |
| IV | Tumor of any size fixed to bone, or fixed, ulcerated lymph node metastases, or distant metastases |
| IVA | Disease fixed to pelvic bone, or fixed or ulcerated regional[b] lymph node metastases |
| IVB | Distant metastases |

[a]Depth of invasion is measured from the basement membrane of the deepest, adjacent, dysplastic, tumor-free rete ridge (or nearest dysplastic rete peg) to the deepest point of invasion.

[b]Regional refers to inguinal and femoral lymph nodes.

Adapted from Olawaiye AB, Cotler J, Cuello MA, et al. FIGO staging for carcinoma of the vulva: 2021 revision. *Int J Gynecol Obstet*. 2021;155(1):43-47. Reprinted by permission of John Wiley & Sons, Inc.

# SURGERY FOR PREINVASIVE DISEASE OF THE VAGINA

There are several ways to treat vaginal dysplasia (VAIN II/III), and these include surgery, $CO_2$ laser vaporization, topical therapies, and radiation. Loop electrosurgical excision is not recommended. In a retrospective study that included 368 patients with VAIN II/III, laser therapy and excisional procedures were associated with regression rates significantly higher than for topical therapy and observation. Surgical excision should be the default initial treatment as up 10% of patients with VAIN III may have an occult invasive lesion. Other studies suggest that for appropriately selected VAIN II/III patients in whom cancer is reasonably excluded, laser vaporization and excisional procedures may perform equally well to achieve clinical regression. Ultimately, treatment modalities should be tailored to the clinical scenario in accordance with clinical judgment.

## Vaginal Biopsy

At initial encounter, it is important to perform an examination for concurrent cervical, perianal, and vulvar lesions as it has been reported that 57% of women with VAIN II/III have had previous lower genital tract dysplasia at another site. Vaginal lesions can be located anywhere along the vaginal epithelium, and careful examination is both critical and potentially challenging. Multifocal disease is present in 42% of patients with VAIN II/III, and only 55% of patients had lesions that were isolated to just the upper vagina. Locating lesions and obtaining a biopsy can be challenging because of vaginal anatomy and patient discomfort associated with biopsies. Rotating the speculum to the anteroposterior orientation to view the anterior and posterior vaginal walls in addition to lateral walls is critical since lesions can be obscured by the speculum blades.

Biopsy of vaginal lesions can be safely accomplished in the office setting. All abnormal lesions should be sampled. Most upper vaginal lesions do not require anesthetic for biopsy, while the lower distal vagina is more sensitive. Biopsy can be obtained with punch biopsy, Tischler biopsy forceps, or by elevating the mucosa with forceps and excising the focal area with scissors. Documentation of the lesion location should be carefully noted. Hemostasis can be achieved with Monsel solution, silver nitrate, or suture if necessary. Providers should have a low threshold to perform an examination under anesthesia, with or without colposcopy, and biopsy suspicious areas in the operating room if that will be the only way to provide an appropriate evaluation of the entire vagina and to sample all abnormal lesions.

VAIN I is not a premalignant condition and does not necessarily require treatment. VAIN II/III requires treatment due to its precancerous nature and risk of both underlying cancer at the time of diagnosis and potential for progression to malignancy, which has been reported in up to 12% of patients.

## $CO_2$ Laser Vaporization

Before considering laser vaporization for treatment of VAIN II/III, one must be convinced that invasive disease has been reasonably excluded by tissue sampling and that all areas that require treatment can be visualized. Laser vaporization can be performed either in the office setting or in the operating room. $CO_2$ laser vaporization has the advantage of simultaneous treatment of multiple vaginal lesions as well as the ability to treat the cervix and/or vulva if high-grade dysplasia is present at those sites as well.

When performing $CO_2$ laser for treatment of VAIN II/III, less power should be used for the vagina than for the cervix. A continuous setting of 10 W is chosen for most vaginal epithelia, although <10 W may be used if the vagina is atrophic. Pinpoint settings should be avoided. The principle is to vaporize the entire depth of the vaginal epithelium, which should be performed to a uniform depth of 3 mm to achieve full-thickness treatment. The goal

should be for a margin of 1 cm from the edges of the visible lesion if possible.

## Vaginectomy

Vaginectomy, surgical resection of vaginal mucosa, is another treatment option for VAIN. This can be either partial or total depending on the extent and location of disease, prior treatments, and the clinical situation. Total vaginectomy for preinvasive disease should be considered a treatment of last resort as it can cause vaginal scarring, stenosis, and impact quality of life. Vaginectomy of the upper vagina for treatment of VAIN II/III usually includes the upper apex alone. Regardless of the type of vaginectomy or its extent, patients should be counseled about risks of bleeding, infection, and scarring, which may result in vaginal stenosis, dyspareunia, and alteration of sexual function.

Surgical excision has the advantage over laser vaporization in that tissue is obtained for complete pathologic analysis. Most vaginectomies can be accomplished primarily by a vaginal approach. Some scenarios may require laparoscopy or laparotomy, especially in cases of VAIN II/III in vaginal vault recesses that occur after hysterectomy.

Vaginectomies are performed under general or neuraxial anesthesia in the operating room. Colposcopy with acetic acid solution and Lugol solution is performed at the time of the procedure to identify the extent of the lesion to be excised. The goal of excision includes a margin 1 cm wide of the visible lesion with excision of the full thickness of the epithelium. Excision can be performed with a scalpel or with forceps and scissors. Some advocate for subepithelial hydrodissection with sterile saline injection or with local anesthetic. Repair is typically accomplished in either a running fashion or with interrupted absorbable suture such as polyglactin. If the defect is small, this can be left open to heal secondarily after obtaining hemostasis.

Some clinicians feel that upper vaginectomy is the treatment of choice for VAIN II/III in the vaginal apex, especially after prior hysterectomy, because up to 28% of these lesions will harbor

underlying malignancy. More contemporary data report a lower incidence of 12%, with a VAIN II/III cure rate of 88%.

If indicated, a hysterectomy can be combined with resection of VAIN II/III. The level at which the vagina must be excised should be delineated and marked at the beginning of the procedure. The hysterectomy is started in the usual manner. Depending on the amount of the vagina that must be excised, a radical hysterectomy with lateralization of the ureters from the parametria (and/or paracolpos) may be required in addition to development of the rectovaginal space to resect the affected vaginal area.

If a previous hysterectomy has been performed, both vaginal- and abdominal (peritoneal)-based approaches for vaginectomy have been described. When a total vaginectomy is performed using a vaginal approach, a circumferential incision is made proximal to the hymenal ring, and the vaginal epithelium is dissected away from the underlying structures in a 360° fashion. This technique may be started at any point higher in the vagina if only a partial vaginectomy is planned. Tissue clamps can be placed along the lateral aspects of the vaginectomy near the location of pudendal arteries in the distal vagina and the vaginal branches of the uterine artery proximally. Care must be taken to avoid trapping the ureters in the clamps. The rectum, bladder, and particularly the urethra are at risk for injury during the dissection.

An abdominal approach starts with identification of and removal of any adhesions of the bowel and/or bladder to the vaginal cuff. The bladder is dissected free, and the rectovaginal septum is developed. The ureters are identified and displaced laterally as would be done during a radical parametrectomy. The use of a vaginal manipulator with gauze on a ring forceps or end-to-end anastomosis (EEA) sizer will likely be necessary to carry out the dissection. Cystoscopy is recommended after the procedure to test the anatomy and patency of the bladder and ureters. “Bubble” testing of the rectum should also be undertaken to detect an occult bowel injury. This is performed by instilling sterile fluid into the pelvis, blocking the large bowel proximal to the surgical site, and instilling air into the rectum using a proctoscope or large syringe. The lack of bubbles observed in the pelvic fluid is reassuring that there is no enterotomy.

Various approaches are available for closure of the vagina depending on the patient's preferences for future sexual function. Consultation with a reconstructive surgeon may be necessary. If the patient does not desire future vaginal function, then closure of the external vaginal skin/introitus with or without vaginal or peritoneal drain placement is performed. Care must be taken to not kink or obstruct the urethra when closing the vagina (**BOX 26.1**).

## BOX 26.1 STEPS IN THE PROCEDURE

### Preparation for Vaginectomy

- Lithotomy position, surgical prep, bladder drainage.
- Drape surgical sites as applicable (perineum, groins, abdomen).

### Upper Vaginectomy for VAIN at Apex (Vaginal Approach)

- Mark margin of required excision (not applicable if concomitant hysterectomy being performed).
- Incision with scalpel.
- Circumferential dissection of the vaginal epithelium.
- Removal of the vagina with or without hysterectomy.
- Achieve hemostasis, perform vaginal closure, possible reconstruction.

### Upper Vaginectomy for Cancer (Peritoneal Approach)

- Vaginal marking to the margin of expected excision
- Abdominopelvic exploration
- If female pelvic organs present, radical hysterectomy
- Ureterolysis

- Pelvic lymphadenectomy
- Development of paravesical, pararectal, vesicovaginal, and rectovaginal spaces
- Dissection to the level of the vaginal marking
- Achieve hemostasis, vaginal cuff closure, or reconstruction
- Cystoscopy
- Close surgical sites

# SURGERY FOR VAGINAL CANCER

Radiation therapy is the primary treatment for vaginal cancer. However, some patients with early stage I or II disease may be treated with radical surgery. Potential candidates for primary surgical treatment are those who have small lesions in the upper one-third of the vagina that are located either posteriorly or laterally. Surgery would include a radical hysterectomy (if the uterus is present), upper vaginectomy, and bilateral pelvic lymphadenectomy similar to surgical therapy for early-stage cervix cancer. Surgery should achieve a margin of 1 cm from the visualized cancer. If a prior hysterectomy has been performed, then radical upper vaginectomy with pelvic lymphadenectomy can be considered. Lymph node drainage of the upper two-thirds of the vagina is through pelvic lymph node basins, and these nodes should be removed at the time of surgery. However, the clinician should be advised that the lymphatic drainage of vaginal cancer is not as precise as for other gynecologic cancer disease sites. While upper one-third lesions generally track to the pelvic lymph nodes and lower one-third lesions to the inguinal lymph nodes, lymph nodes in both the inguinal and pelvic regions may be at risk with any vaginal cancer. A study of sentinel lymph nodes (SLNs) drainage in vaginal cancer reported 14 patients in whom 11 had an SLN identified using radiolabeled colloid and patent blue dye. Of these 11 patients, sentinel inguinal nodes were identified in 6, pelvic sentinel node in 3, and nodes in both areas were identified in 2.

Isolated early-stage lesions in the distal vagina may be amenable to surgical excision. However, this may require both vaginectomy and vulvectomy and lead to a significant risk of postoperative infection, wound breakdown, scarring, and sexual dysfunction. If surgical resection is undertaken for a vaginal cancer that involves the distal one-third of the vagina, inguinal lymph node dissection should be performed because metastases to inguinal lymph nodes will be present in 16% of cases.

For select stage II, stage III, or stage IV lesions, or central postradiation recurrences with or without vesicovaginal or rectovaginal fistula, pelvic exenteration can be considered, although this is rarely recommended. The number of candidates with greater than stage I disease who would be eligible for exenteration is limited since involvement of lateral paravaginal tissues would be a relative contraindication. A laterally extended endopelvic resection with excision of pelvic side wall musculature has been described with complications similar to pelvic exenteration in the range of 70%-80%.

# SURGERY FOR PREINVASIVE DISEASE OF THE VULVA

## Diagnostic Vulvar Biopsy

Vulvar biopsy can be accomplished safely in the office setting. The base of the lesion is injected with local anesthetic without epinephrine, and a punch biopsy with a gentle twisting motion is used to obtain a small piece of tissue. The bleeding from 3- to 4-mm punch biopsies can usually be controlled with topical agents, but 5- to 6-mm biopsies typically need closure with suture. Biopsy at the edge of lesion has been traditionally advocated. However, biopsy should target the middle of most suspicious area to avoid missing the most severe aspect of the lesion. At times, more than one biopsy of a single lesion is warranted. If multiple vulvar biopsies or “mapping” biopsies of full-field lesions are required, an examination under anesthesia with biopsies in the outpatient operating room may be preferred. Persistent vulvar lesions should be rebiopsied as they

can harbor high-grade dysplasia or an invasive cancer that was not identified on previous attempts.

In some scenarios, the biopsy may contain only benign pathology. As noted above, the clinician should harbor a healthy suspicion of preinvasive or invasive disease for nonhealing lesions or those that have a concerning clinical presentation. It may be appropriate to recommend a larger excisional biopsy in the outpatient operating room in these cases. The technique for these excisional biopsies should follow that for a simple vulvectomy as described below. Additional discussion of the technique of vulvar biopsy is reviewed in Chapter 17.

High-grade VIN is treated with surgical excision, $CO_2$ laser ablation, ultrasonic surgical aspirator, or topical agents. Another option is treatment with the topical agent imiquimod, which is applied to the lesions for 16 weeks and associated with a complete response rate of 51% (**FIG. 26.2**).

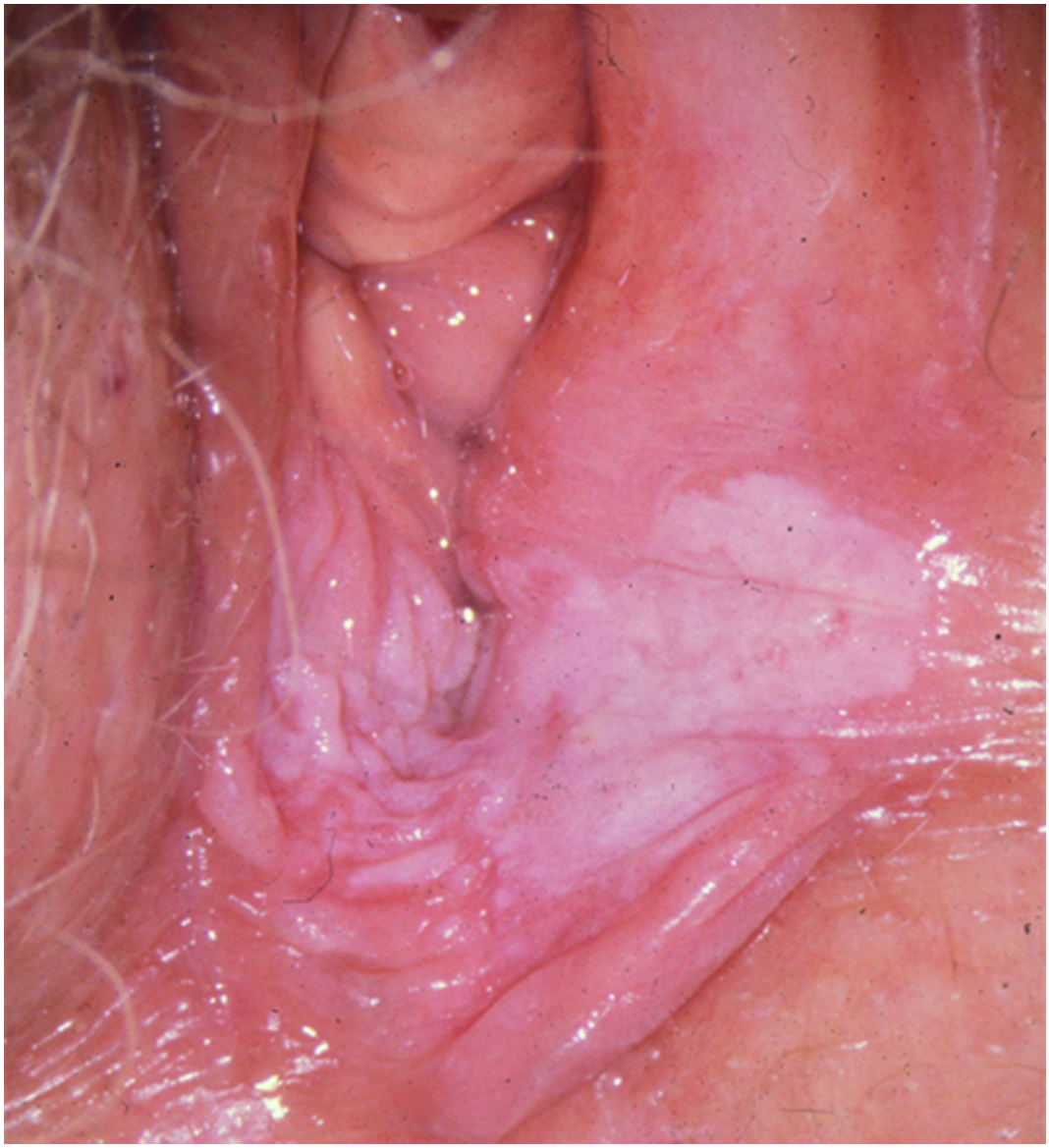

**FIGURE 26.2** VIN III (vulvar carcinoma *in situ*) after application of acetic acid.

Surgical excision is recommended for ulcerated, raised lesions with irregular borders, patients with prior VIN or cancer, patients who are chronically immunocompromised, older patients, and those with differentiated VIN as the risk of occult cancer may be up to 33%.

Simple vulvectomy, also called wide local excision, refers to surgical resection of any size that removes the epidermis, dermis, and a small portion of underlying tissue. Total simple vulvectomy

refers to a specific procedure performed for multifocal or full-field disease in which a significant portion of the dermis and epidermis is removed from most, if not all, of the vulva. Split-thickness skin grafting may be required to repair the defect. This contrasts with a radical vulvectomy where the depth of excision is taken to the level of the fascia overlying the urogenital diaphragm, perineal fascia, or the pubic bone periosteum.

## $CO_2$ Laser Vaporization

This technique follows similar steps as with treatment of VAIN II/III and cervical intraepithelial neoplasia. Before considering laser vaporization for treatment of usual type high-grade VIN (vulvar HSIL), the provider must be convinced that invasive disease has been reasonably excluded with liberal tissue sampling. Laser vaporization may be optimal for younger patients with multifocal disease as they are at lower risk for occult invasive disease. The same safety training, operative setup, and safety precautions required for $CO_2$ laser vaporization of the cervix are applicable.

The power settings are similar to those used in vaginal laser with a continuous setting of 10 W on average and 5 W for atrophic tissue. Colposcopy and acetic acid should be applied to demarcate affected areas, and a margin of 0.5-1 cm is recommended. Because VIN can extend into hair follicles, deeper ablation is required in hair-bearing areas. The colposcope or sight piece of the laser should permit recognition of these tissue planes. Recent guidelines recommend destruction to a depth of 2 mm in non–hair-bearing areas and 3 mm in hair-bearing regions.

## Simple Vulvectomy

Most patients require only a partial simple vulvectomy to excise the visible lesion with a 0.5- to 1-cm margin. The goal is to preserve as much normal anatomy and sexual function as possible. Colposcopy and acetic acid solution should be applied to aid in margin identification. Some patients may require a total simple vulvectomy; however, this procedure should be performed sparingly. Total simple

vulvectomy with or without skin graft reconstruction is a procedure generally performed in young women with extensive and/or multifocal high-grade VIN, widespread extramammary Paget disease of the vulva, and patients in whom there is no other way to rule out invasive cancer. If skin grafting is required, there can be additional scar formation at the donor site and often the patient needs prolonged bed rest, lower extremity immobilization, and indwelling bladder catheterization while the graft undergoes initial healing. In modern practice, this is performed by reconstructive surgeons. While the recurrence risk is 20% for all surgical modalities, simple vulvectomy with negative surgical margins has a recurrence risk of 10%-15% but can be as high as 30%-50% with positive margins.

To perform a partial simple vulvectomy, an outline is made with a surgical marker around the visible lesion with a 0.5- to 1-cm margin. Attention should be paid to anatomy and the plan for closure, tailoring the outline accordingly. Only in rare circumstances should critical urogenital structures such as the clitoris, distal urethra, anal sphincter muscles, or anus be resected. The incision should be made with a scalpel to avoid obscuring surgical margin assessment. Once the skin is incised, dissection can be performed either with a scalpel or with an electrosurgical instrument to a uniform depth of 3 mm or to the adipose tissue (to include the entire epidermis and dermis). Some adipose may be removed to facilitate deep margin assessment or closure of the defect. The resection can be carried to a very close proximity to the anal verge, but careful dissection of the anal mucosa from the anal sphincter must be undertaken. Areas of bleeding throughout the dissection can be made hemostatic using electrosurgery or suture ligation. Caution should be exercised with electrocautery near the urethral orifice, on the perineum, and in perianal regions. Certain medical issues, prior surgical procedures, and/or birth trauma may bring the urinary and bowel tracts closer to the resection area than anticipated. Closure should be performed in layers with interrupted absorbable suture in the subepithelial tissues to take tension off the final layer of closure. Skin closure is accomplished with simple interrupted or mattress suture with undyed 2-0 to 4-0 polyglactin (**BOX 26.2**).

## BOX 26.2 SIMPLE VULVECTOMY

- Perform colposcopic evaluation and apply acetic acid.
- Mark 0.5 to 1-cm margins from visible lesion circumferentially (if reasonable, given anatomy).
- Adjust marking to account for sensitive structures such as urethra and clitoris if these are not to be resected.
- Perform skin incision with scalpel.
- Remove skin and subcutaneous tissues.
- Orient specimen for pathologic analysis.
- Achieve hemostasis, subcutaneous closure as needed.
- Close skin layer.

When a total simple vulvectomy is indicated, the initial incision should be made around the vaginal introitus. Packing is placed in the vagina after this initial inner incision while the outer incision is made. The outer incision generally includes the entire labia minora and majora but can be tailored to the extent of the lesion(s). A scalpel should be used to avoid coagulation artifact at the margins. The epithelium is dissected using either a scalpel or an electrosurgical instrument as described above for the partial simple vulvectomy, and closure proceeds in a similar fashion. Preoperative consultation with a reconstructive surgeon should be scheduled in case local/regional flap mobilization or skin graft is needed. Patient anatomy, body habitus, prior surgery, or radiation to the area and extent of resection will determine need for reconstruction. If there is plan to remove the affected clitoris, the surgeon must discuss the potential serious side effects on future sexual function prior to the procedure (**FIG. 26.3**).

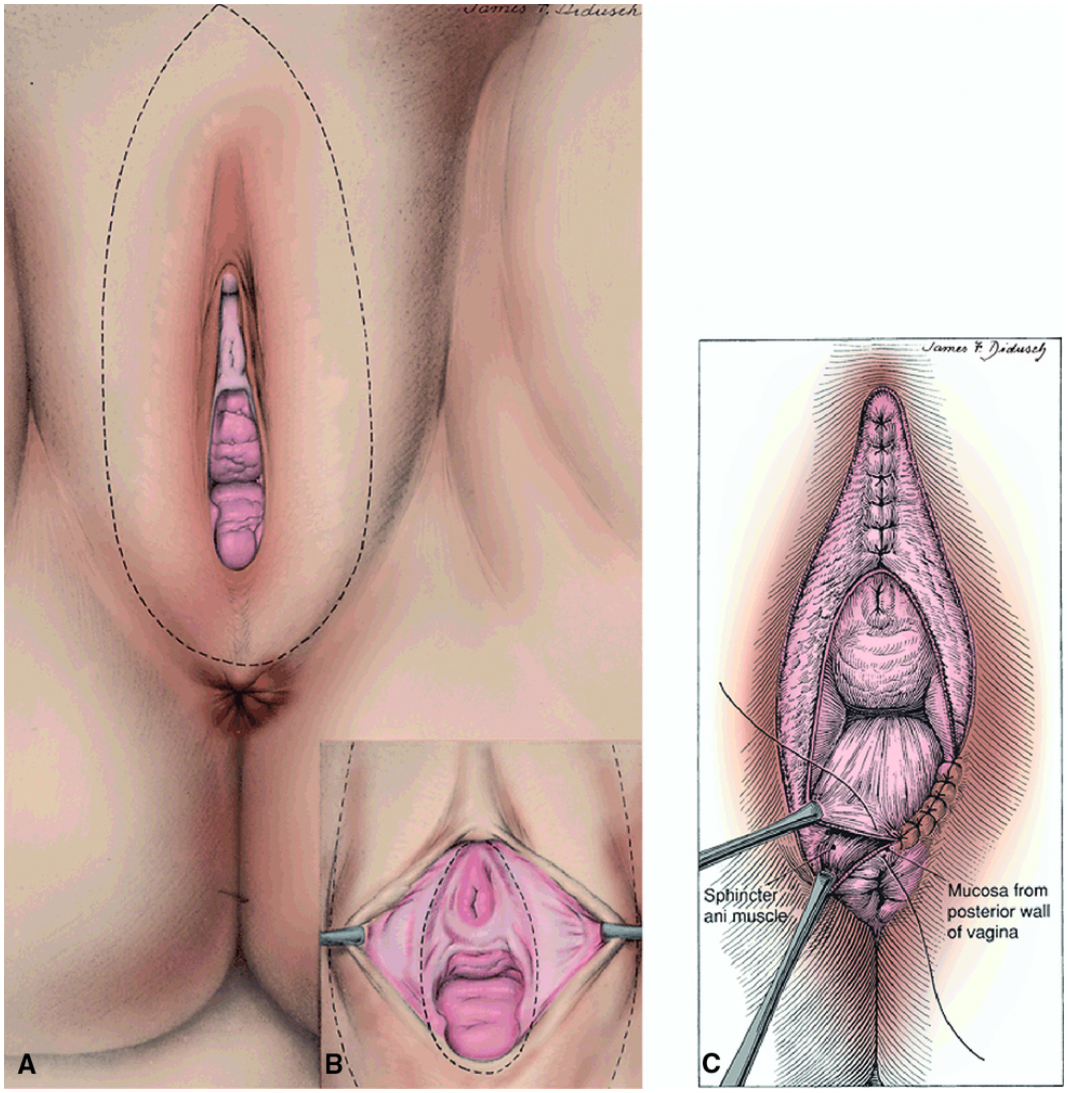


**FIGURE 26.3 A-C.** Technique for total simple vulvectomy (see **Box 26.2** for Steps in Procedure for Vulvectomy).

# SURGERY FOR VULVAR CANCER

Surgical treatment for primary vulvar cancer ranges from a simple vulvectomy for stage IA disease to a modified radical vulvectomy with unilateral or bilateral lymph node dissection for more extensive disease. Additionally, comorbid conditions, age, and perceived ability to tolerate a radical surgery should be considered when undertaking

surgical planning. For large lesions and lesions encroaching on the urethra, bladder, ascending the vagina, or near the rectum, starting with radiation treatment is recommended. The decision to start treatment with radiation is made by the gynecologic oncologist and radiation oncologist (**FIG. 26.4**).

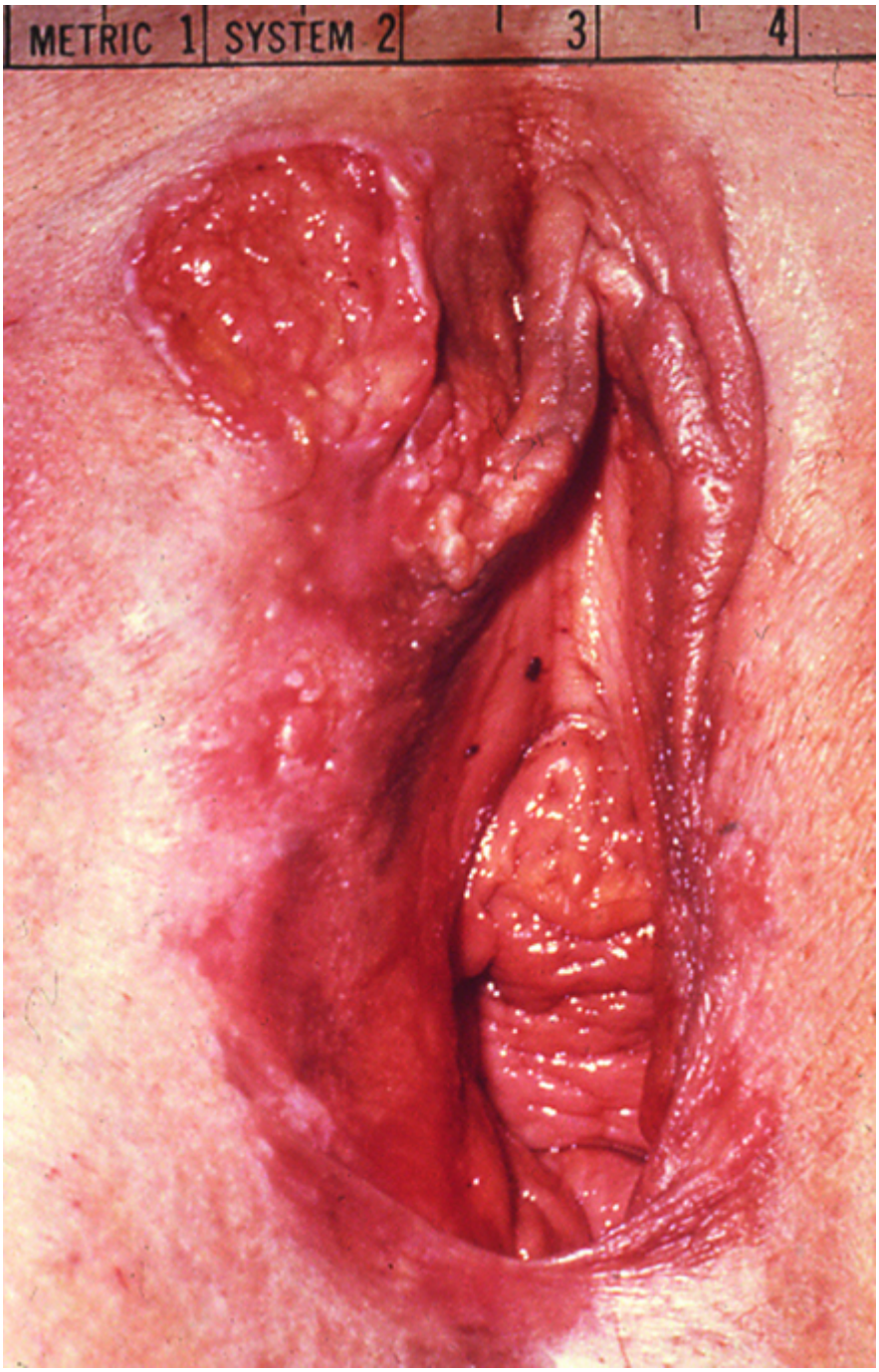

**FIGURE 26.4** Invasive squamous cell carcinoma of the right anterior vulva.

Historically, a classic “butterfly” incision was made to complete a total radical vulvectomy and bilateral inguinofemoral lymph node dissection. This procedure involved a radical resection of the entire vulva, mons pubis, and inguinofemoral lymph nodes *en bloc*. Patients experienced significant morbidity, including high rates of wound breakdown, infection, prolonged hospitalizations, and disfigurement. This procedure is rarely considered or indicated for treatment of vulvar cancer in the modern era (**FIG. 26.5**).

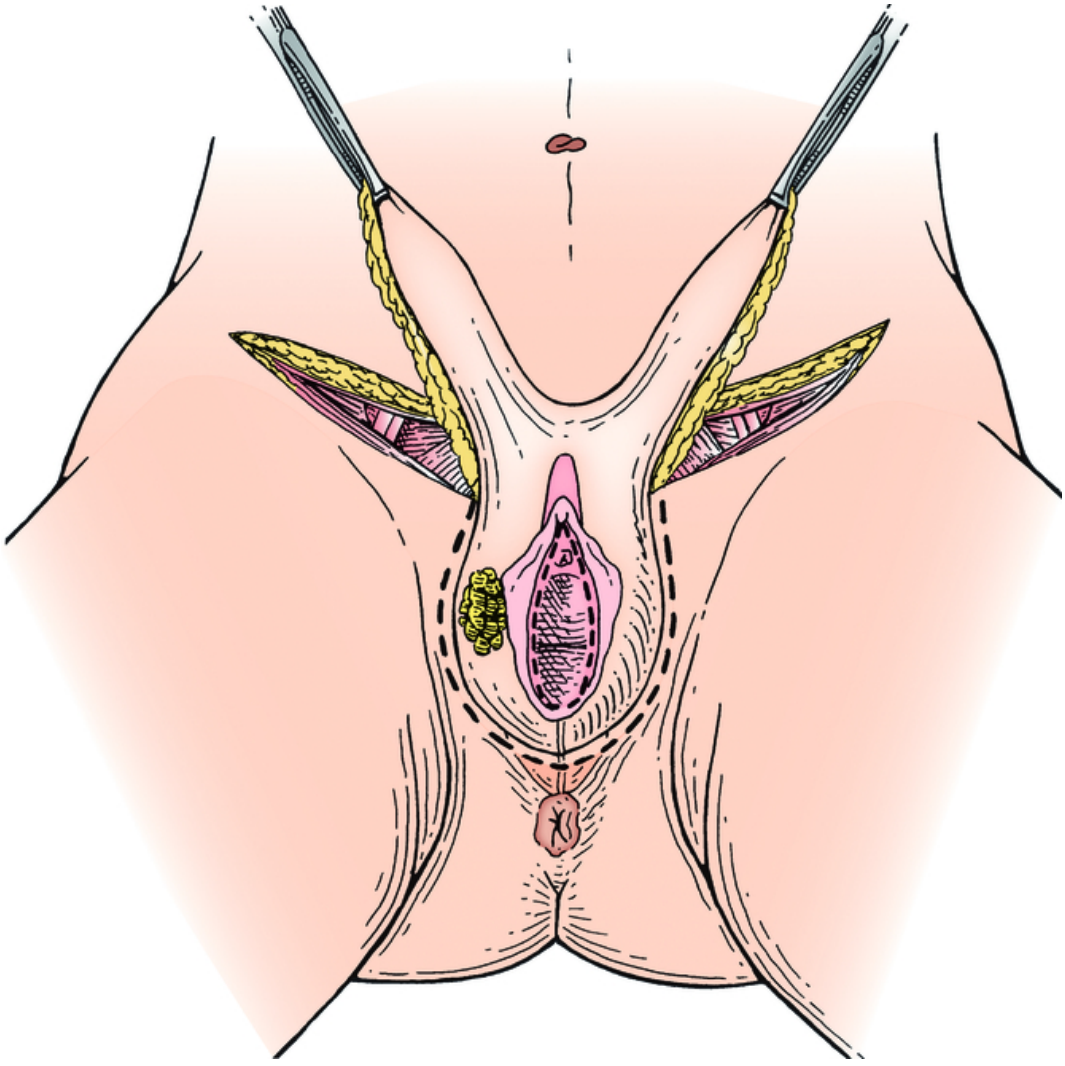

**FIGURE 26.5** Classic *en bloc* resection for total radical vulvectomy and bilateral inguinofemoral lymphadenectomy.

A more appropriate approach is the modified radical vulvectomy (often referred to simply as the radical vulvectomy). In this procedure, the surgeon excises the entirety of the visual tumor, with a circumferential 2-cm skin margin measured from the tumor edges and continues to the depth of the fascia of the urogenital diaphragm, perineal fascia, or pubic bone periosteum.

## Radical Vulvectomy

A radical vulvectomy with a separate groin incision(s) is the current surgical approach to most vulvar cancer surgeries. Examples of vulvar incisions that allow for optimal closure are shown in **FIGURES 26.6 and 26.7**. In cases with small tumors, the incision may be even more attenuated adjusting for the size of the lesion. Regardless of tumor size, a 2-cm margin of normal-appearing skin or mucosa around the tumor should be marked prior to making an incision, if possible. This may require excision of a portion of the distal urethra, vagina, or anus/anal sphincter complex. Issues involving these specific resections are discussed below. Anterior lesions may require removal of the clitoris, and posterior lesions require resection of at least some portion of the perineal body. For dissection of deep posterior lesions, the surgeon should place a finger in the anus to guide resection and avoid close contact with, and/or accidental perforation of the anal/rectal mucosa. Additionally, posterolateral lesions near 4 and 8 o'clock relative to the vaginal introitus will require deep dissection near the pudendal arteries, and care should be taken to identify, clamp, and ligate these vessels.

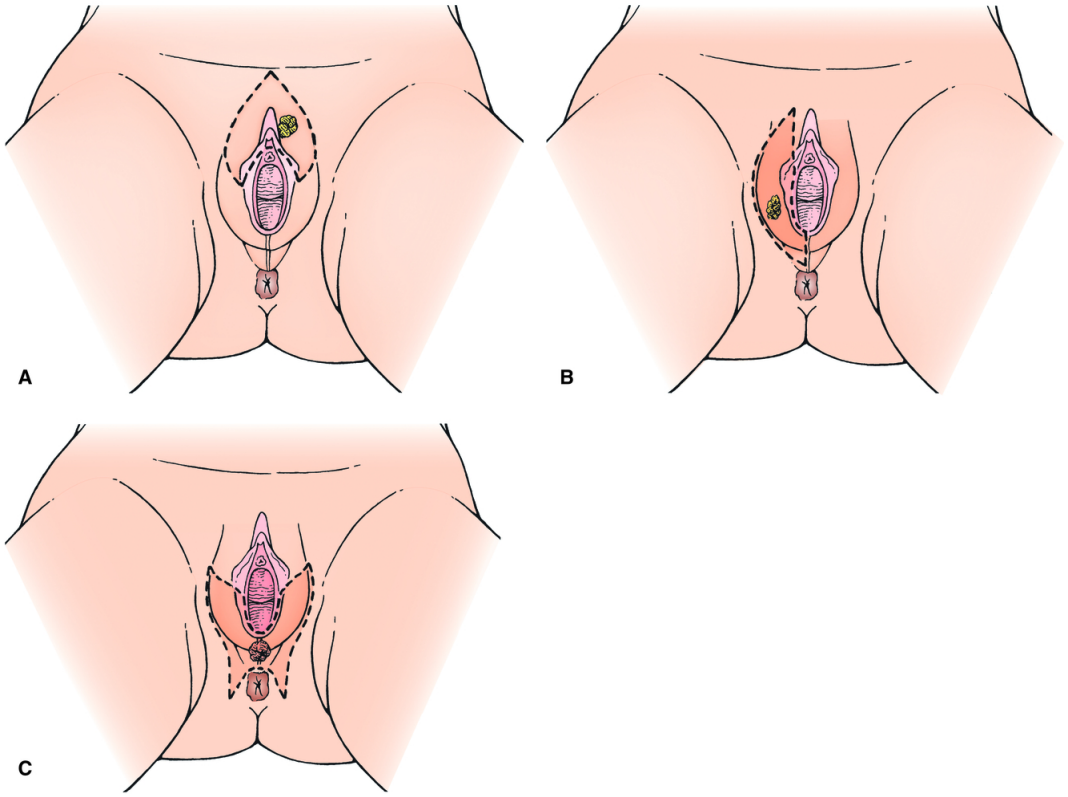


**FIGURE 26.6** Modified radical vulvectomy. **A.** Anterior hemivulvectomy. **B.** Right hemivulvectomy. **C.** Posterior hemivulvectomy.

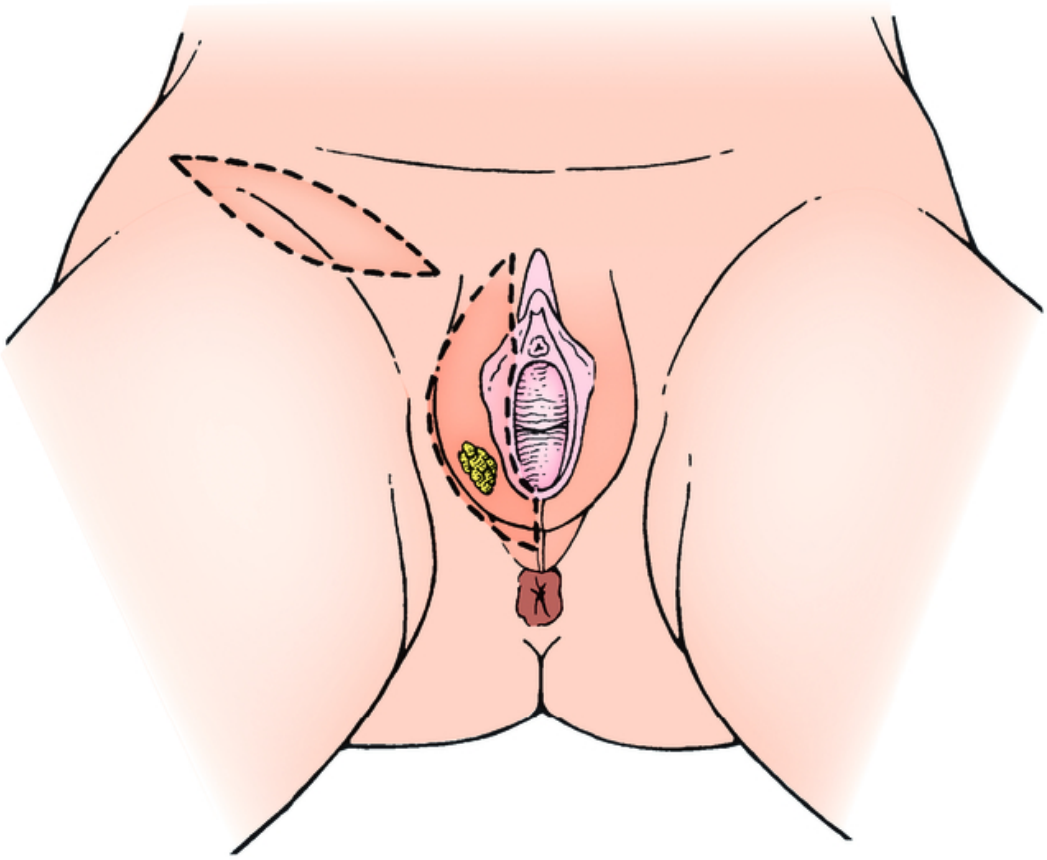

**FIGURE 26.7** Unilateral complete lymphadenectomy in a patient with a right modified radical vulvectomy.

This skin incision should be made with a scalpel to avoid cautery artifact at the tissue margins and then carried through the dermis with either the scalpel or monopolar electrosurgical pencil. With the use of an assistant, traction and countertraction is applied to opposing edges of the incision with either forceps or Allis clamps.

Dissection down to the urogenital fascia (also called deep fascia) can be performed in a variety of ways. Undermining tissue pedicles with an instrument and dividing them with a monopolar electrosurgical pencil, or the use of a handheld bipolar or ultrasonic energy device, are two common techniques. Care should be taken to proceed in a direction perpendicular to the skin incision so as not to undermine the remaining skin, which could lead to necrosis. It is also

important to avoid undermining the specimen and leaving critical at-risk tissues behind. The base of the specimen is dissected away from the appropriately selected deep margin either with clamps and suture ties or with a handheld energy device. Care should be taken to orient the specimen precisely and accurately for pathologic evaluation. This can be accomplished with placement of sutures at critical landmarks or by pinning the specimen to a paraffin orientation chamber specifically designed for this purpose.

After removal of the specimen, the wounds are irrigated, and hemostasis is secured. Interrupted layered closure should be performed with absorbable suture to close dead space and relieve tension from the skin closure. The number of layers will vary based on body habitus, lesion location, and specific clinical situation. Closure of two or three subcutaneous layers is usually needed. The skin can be reapproximated with either interrupted vertical or horizontal mattress sutures with attention to keep the knots on the side of the incision opposite of the urethra and clitoris to avoid irritation of those sensitive structures (**FIG. 26.8**). The periurethral closure merits particular attention as tension that deviates the urethral meatus or a closure that obstructs the urine stream may cause urine stream deviation or spray that may cause permanent urinary issues. The periurethral tissues may be allowed to heal by secondary intention with Foley catheter for a short time to avoid these concerns (**FIG. 26.9** and; **BOX 26.3**).

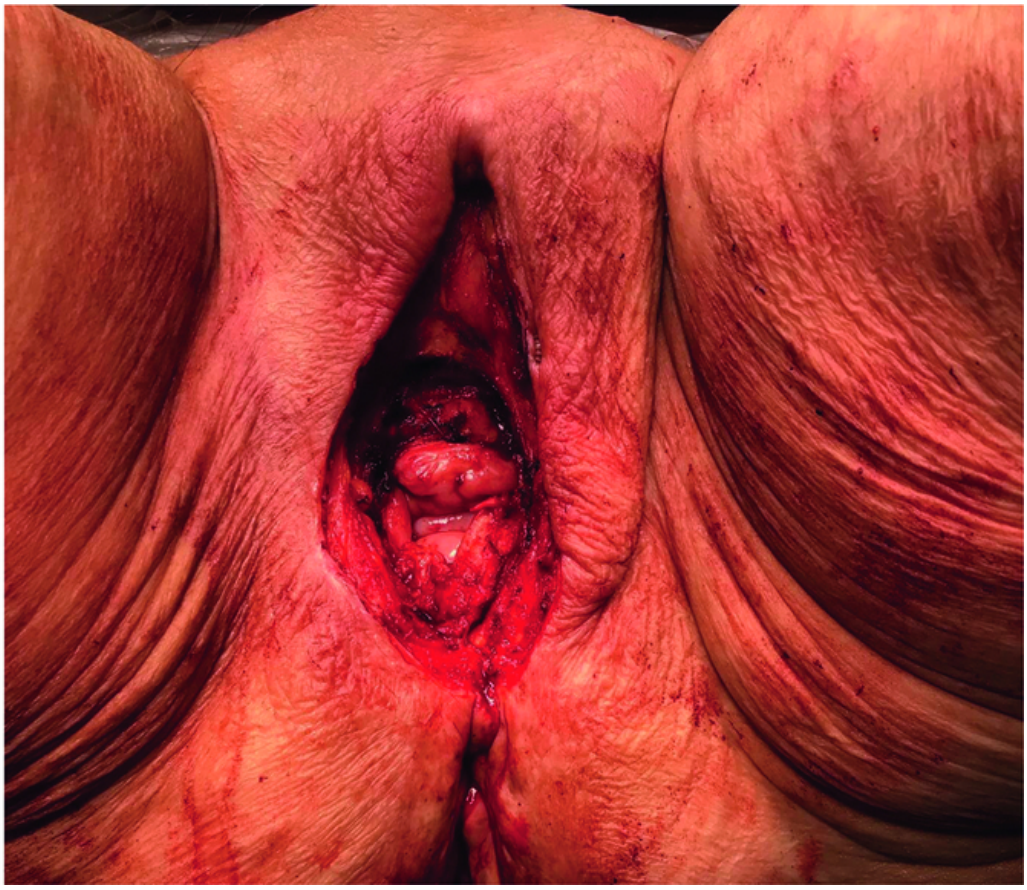

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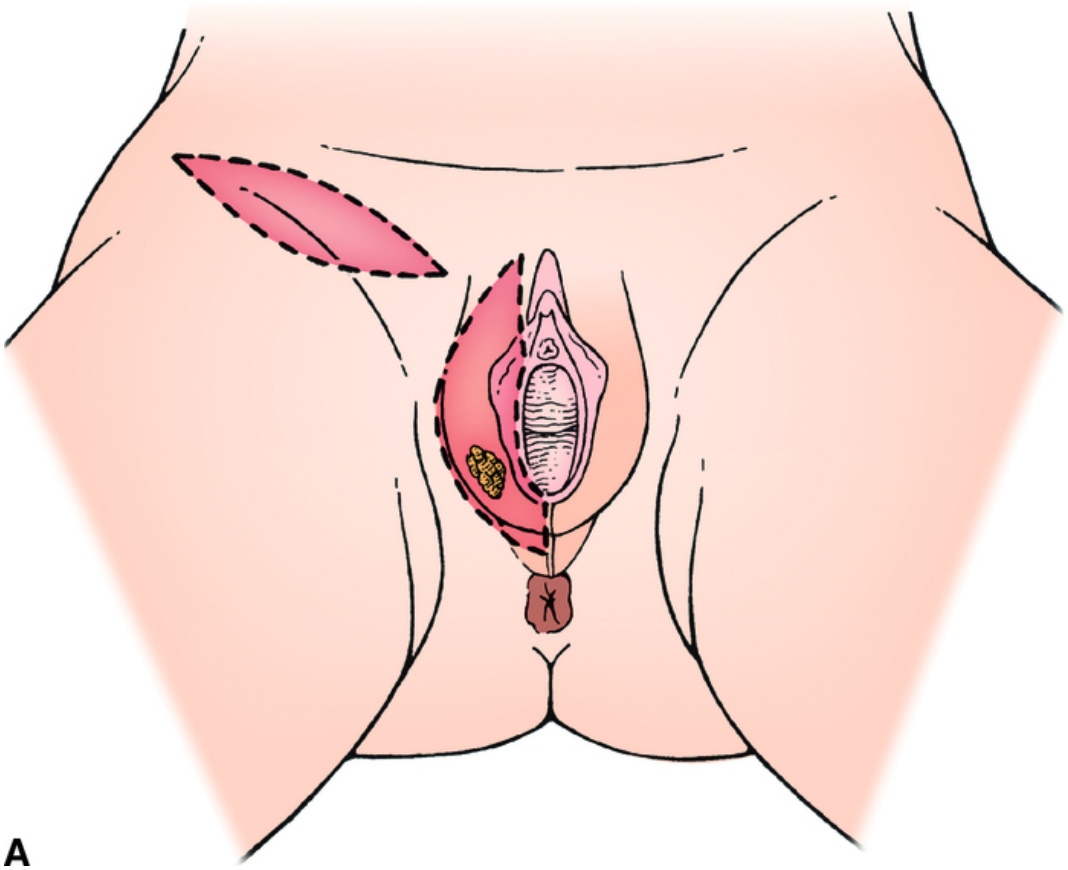
**FIGURE 26.8** Radical vulvectomy with multilayered closure. **A.** Vulva after radical surgery. **B.** Primary closure, performed in layers. **A** and **B**: (Courtesy of David M. Kushner, MD, FACOG; University of Wisconsin School of Medicine and Public Health.)



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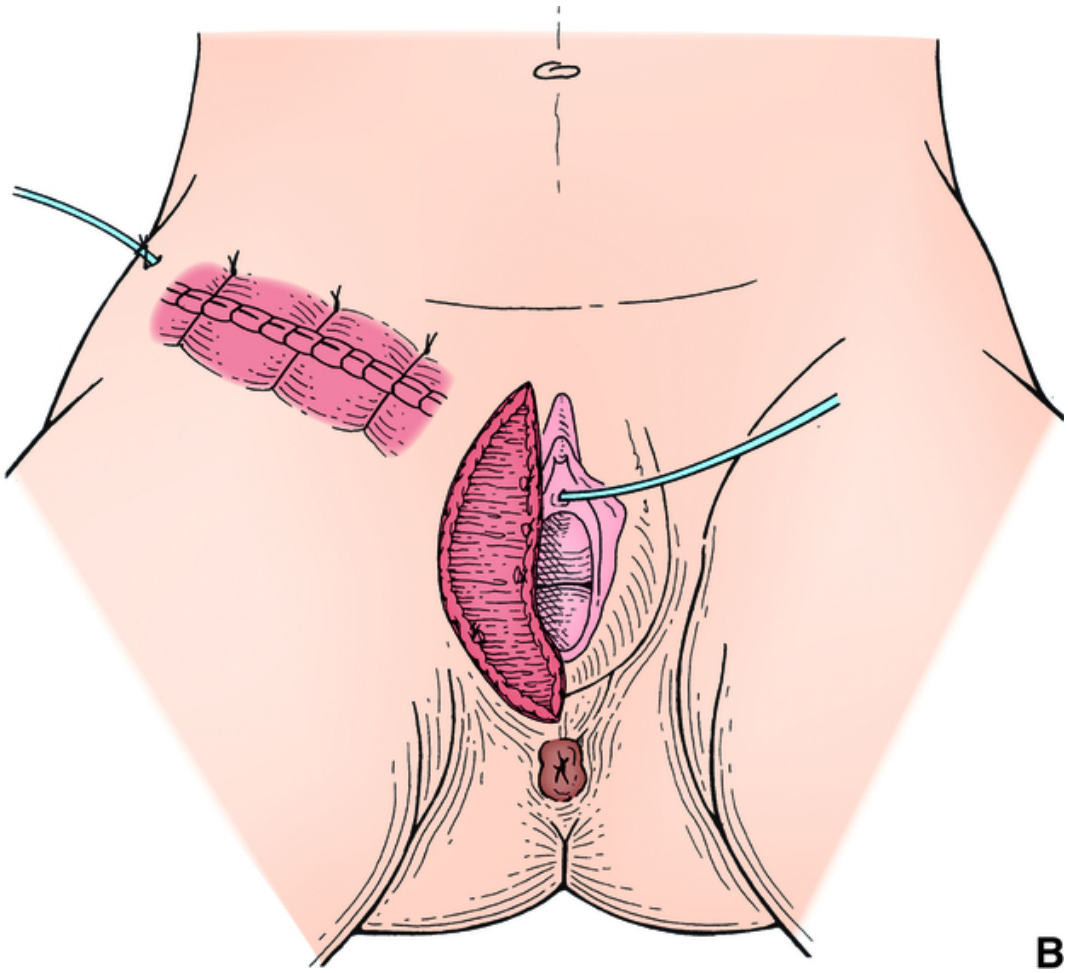

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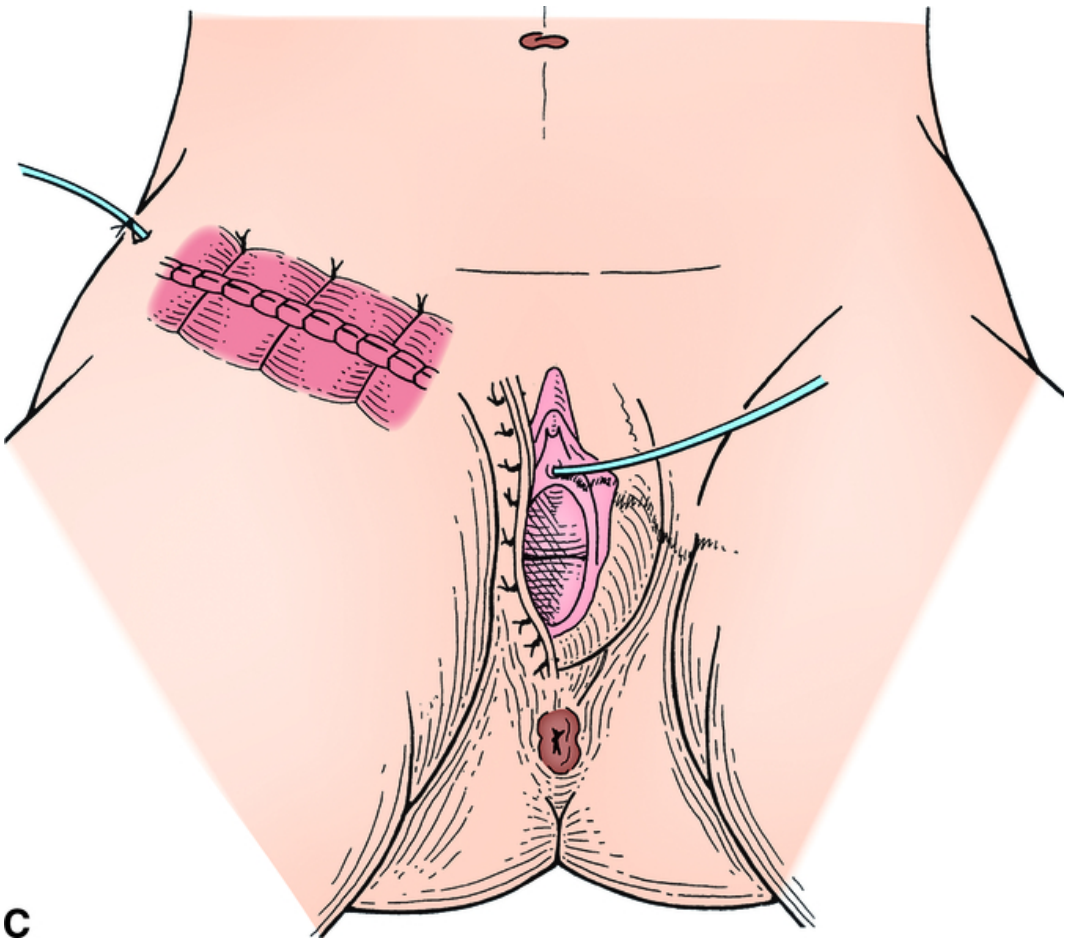

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**FIGURE 26.9 A-C.** Right modified radical vulvectomy with unilateral right inguinofemoral lymphadenectomy. A groin drain is placed and brought out through a separate incision. See **BOXES 26.3** and **26.4** for steps of procedure for radical vulvectomy and lymphadenectomy.

## BOX 26.3 RADICAL VULVECTOMY

- Mark 2-cm margins from visible lesion circumferentially.
- Adjust marking to account for sensitive structures such as urethra and clitoris if resection is not planned.

- Mark reconstruction sites if applicable.
- Perform skin incision with scalpel.
- Continue incision sharply or with cautery to the level of the urogenital diaphragm, perineal fascia, or pubic bone periosteum. If encountered, ligate, and divide the pudendal vessels.
- Divide base of the vulva with cautery and release specimen.
- Orient specimen for pathologic analysis (place suture at 12 o'clock).
- Achieve hemostasis and then close deep layers with 2-0 polyglactin.
- Close skin with interrupted 2-0 to 4-0 polyglactin suture, or if defect is small can consider, subcuticular closure.

# Urethral Resection

Based on the tumor location (with the goal of obtaining a 2-cm surgical margin), it may be necessary to remove a portion of the distal urethra. Preoperative discussion of possible urethral resection should be undertaken and include discussion with a urologist or urogynecologist regarding assistance with urethral reconstruction. The patient should be counseled about the possibility of some urinary dysfunction or incontinence following such a resection. If the distal 1-1.5 cm of urethra is resected, a Foley catheter should be placed for a short period after surgery to facilitate healing of the periurethral tissues and decrease the risk of stricture. Performing an incontinence procedure at the time of resection should be considered. Lesions abutting or involving the urethra can also be treated with preoperative chemoradiation to shrink lesions before proceeding to excision (**FIG. 26.10**).

**FIGURE 26.10** Locally advanced, periurethral squamous cell cancer of the vulva. (Photo courtesy of Linda Van Le, MD; University of North Carolina School of Medicine.)

The area to be resected should be outlined with a surgical marking pen with attention to the depth of the urethra that will be needed to accomplish this margin. After the initial incision around the urethra, a Foley catheter is placed. Although it is increasingly common to use electrosurgical instruments for both the epithelial incisions and for dissection into deeper tissues, caution should be exercised around the urethra to avoid damage from thermal spread. The periurethral tissues should be dissected circumferentially. Absorbable suture can be placed on opposing sides of the urethra for traction and to mark the edges. This is helpful to identify the new urethral orifice if it retracts significantly. The urethra is then transected with Metzenbaum scissors. The new urethral orifice is then approximated to the edges of the vaginal or vulvar epithelium to create the neomeatus. In areas where there is significant tension and/or risk of stricture at the site seems high, hemostasis should be achieved, the defect left open, and the periurethral tissues can be allowed to heal by secondary intent. The Foley catheter should be maintained for 7-10 days.

## Management of Vulvar Cancer With Perianal Involvement

There are few data to guide the surgical decision-making for treatment of vulvar cancer with involvement of the perianal region. Frequently, in cases of extensive disease, obtaining a negative margin may compromise voluntary and involuntary continence mechanisms of the anal sphincter complex. This may result in stool incontinence and require bowel diversion at the time of radical excision or after. Up to 20% of women will develop fecal incontinence after resection of this area with great impingement on quality of life. Due to these issues, neoadjuvant chemoradiation should be strongly considered as primary treatment in these situations (**FIG. 26.11**).

**FIGURE 26.11** Invasive squamous cell carcinoma involving the perineum and perianal skin.

## Inguinofemoral Lymphadenectomy

When considering treatment decisions for vulvar cancer, the surgeon must also plan for evaluation of the groin for lymph node metastases. Inguinofemoral lymphadenectomy has evolved from a total *en bloc* resection that was associated with significant morbidity to an SLN approach with small incisions.

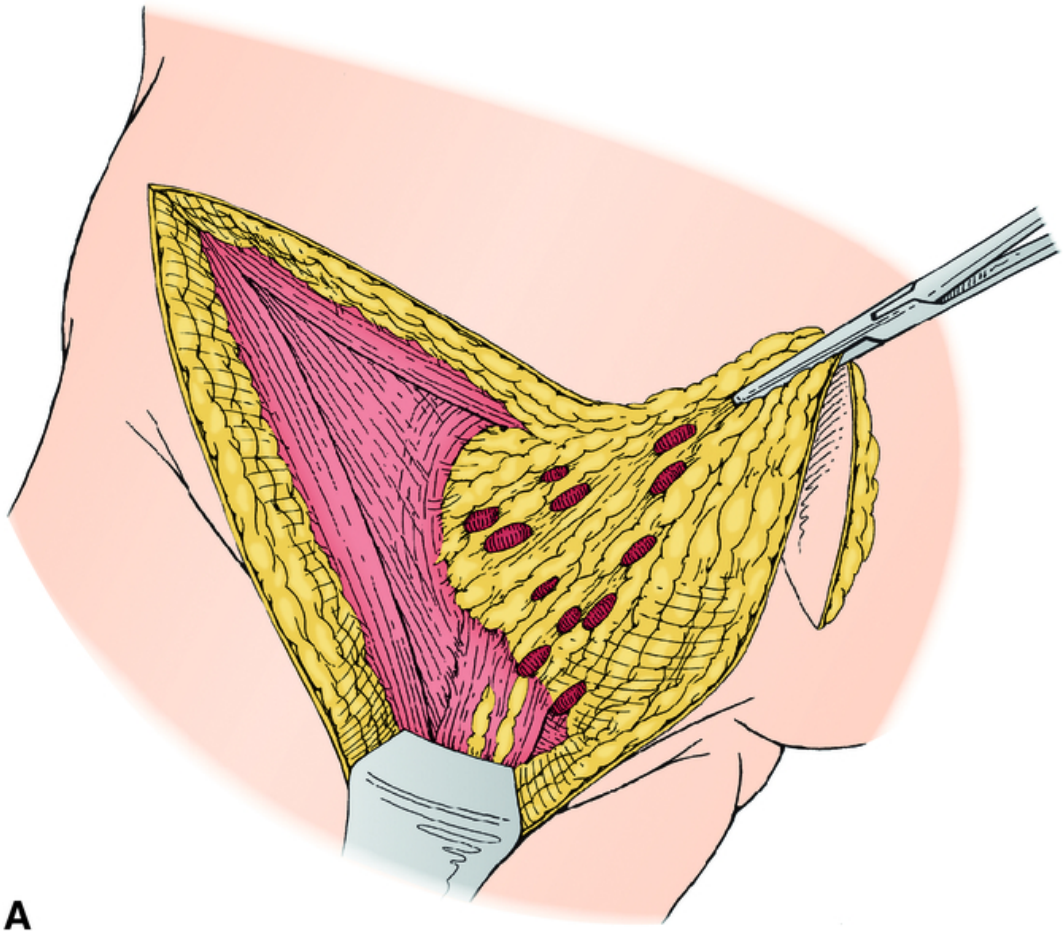
Most women with stage IA disease (≤1 mm depth of invasion and tumor size ≤2 cm) do not need to undergo inguinofemoral lymph node assessment, because metastatic disease for this early stage is low. The exceptions to this include cancers with unusual histologies, prsence lymphovascular space invasion, or if clinically or radiographically suspicious lymph nodes are noted. Cancers with lesions >2 cm in size and with invasion deeper than 1 mm (stage IB) are associated with increased risk of lymph node metastases. For

cancers with invasion of 1.1-3 mm, the risk of lymph node metastases is 7%-8% and if >3-mm invasion is present, the risk increases to 26%-34%, so these patients will require groin lymph node assessment. For anterior cancers, those within 2 cm of midline structures, or those that cross the midline, bilateral groin lymphadenectomy is recommended.

The critical anatomic landmarks for the incision are the anterior superior iliac spine and the pubic tubercle. These points can be connected with a surgical marker to identify the location of the inguinal ligament. The exact location of the incision will be influenced by the location of the groin folds and the body habitus of the patient. One should avoid making the incision in a groin fold as it may heal more slowly and be uncomfortable for patients. The incision could be made either above or below this fold, but it is usually more convenient to make the groin incision between the inguinal ligament and a fold, ~2 cm inferior to the inferior border of the inguinal ligament. The incision will run parallel to the line demarcating the inguinal ligament and will be typically 8-10 cm long and stop about 2 cm lateral to the pubic tubercle. The medial angle of the incision should overlie the medial aspect of the fossa ovalis. Some surgeons will prefer to make a curvilinear or elliptical incision to excise a strip of skin to theoretically decrease the likelihood of skin necrosis that might occur with dissection of underlying tissue and their blood supply. In either case, the procedure begins by dissecting down below the level of the superficial fascial plane and creating flaps under the superior and inferior borders of the incision. The skin and subcutaneous tissue just below the level of Camper fascia should be undermined together. This is performed in both the cephalad and caudal direction, but much more substantially caudally. It is critical to keep this skin flap at full thickness (ie, not undermining too close to the skin) to decrease the risk of skin necrosis. This also separates the subcutaneous fat and skin from the deeper lymph node–bearing tissues that lie just superficial to the fascia lata, cribriform fascia, and fossa ovalis.

The lateral and superior borders of the fatty tissue/lymph node bundle are developed first. In cases where it is challenging to decipher the borders of the sartorius and adductor longus muscles,

the index finger may be used to gently follow the medial aspect of the sartorius muscle and the lateral aspect of the adductor to better define the femoral triangle. Care must be taken to avoid avulsing the long saphenous vein as it will lay in the superficial tissues crossing the medial border of the triangle. The superior border is the inguinal ligament, and the fatty tissue can be dissected off the ligament and begin to be reflected inferiorly. Laterally, the fascia lata is identified, and the lateral border of the dissection is represented by the medial aspect of the sartorius muscle. The fatty tissue is reflected medially and follows the sartorius border inferiorly. If a deep inguinal lymphadenectomy is to be performed, the fascia lata overlying the femoral vessels is incised longitudinally. The nodal bundle consisting of 2-3 nodes (including Cloquet node, the most cephalad of the deep femoral nodes) is dissected from the medial aspect of the femoral vein (**FIG. 26.12**).



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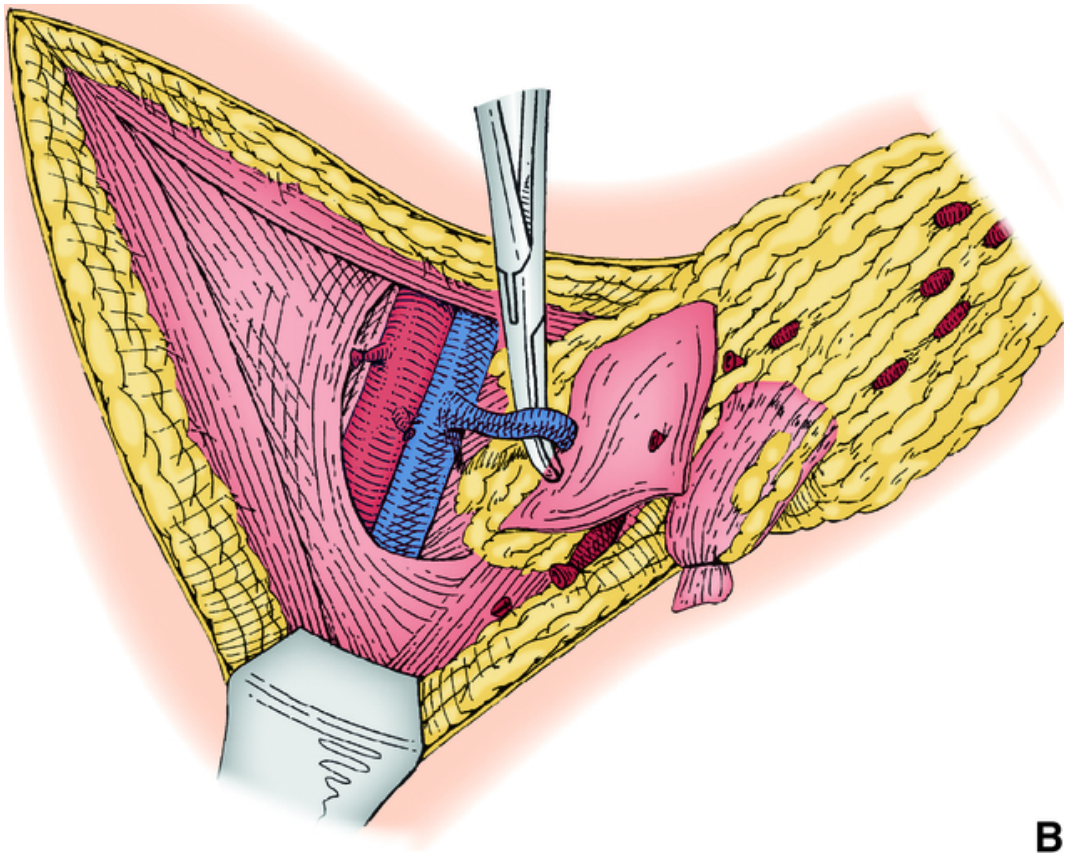

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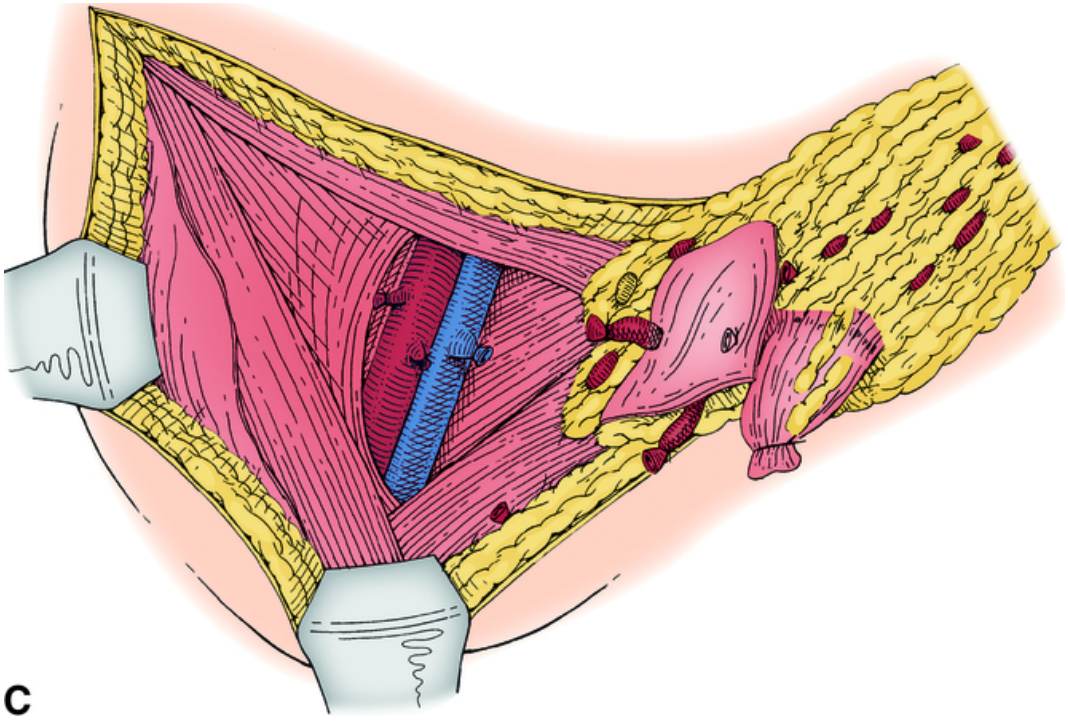


C

**FIGURE 26.12** **A.** Inguinal-femoral lymphadenectomy. The corner of the groin specimen is dissected up from lateral to medially off the sartorius muscle. The lateral portion of fossa ovalis and cribriform fascia are exposed. **B.** The saphenous vein is identified, isolated, clamped, and divided near its entrance into the femoral triangle. **C.** The groin specimen containing the fatty nodal tissue above the cribriform fascia and the femoral nodes below the cribriform fascia are reflected medially exposing the femoral vessels and the insertion of the saphenous vein.

Prior to layered closure, the site is copiously irrigated, and suction drains are placed into the groin and brought out through separate small incisions generally placed above the inguinal ligament and just superior and medial to the anterior superior iliac spine. Drains are placed to relieve collection of lymphatic fluid that results from dissection in this space. A known complication of groin dissection is lymphocyst formation, a collection of lymphatic fluid. Typical drain choices are a 19-French Jackson-Pratt or Blake. The skin can be closed with staples or suture based on clinical assessment. In cases where there is significant tension on the incision, a subcuticular suture or retention sutures can be placed. Drains are typically removed after <30 mL of output in a 24-hour period for 2 consecutive days (**BOX 26.4**).

## BOX 26.4 INGUINOFEMORAL LYMPHADENECTOMY

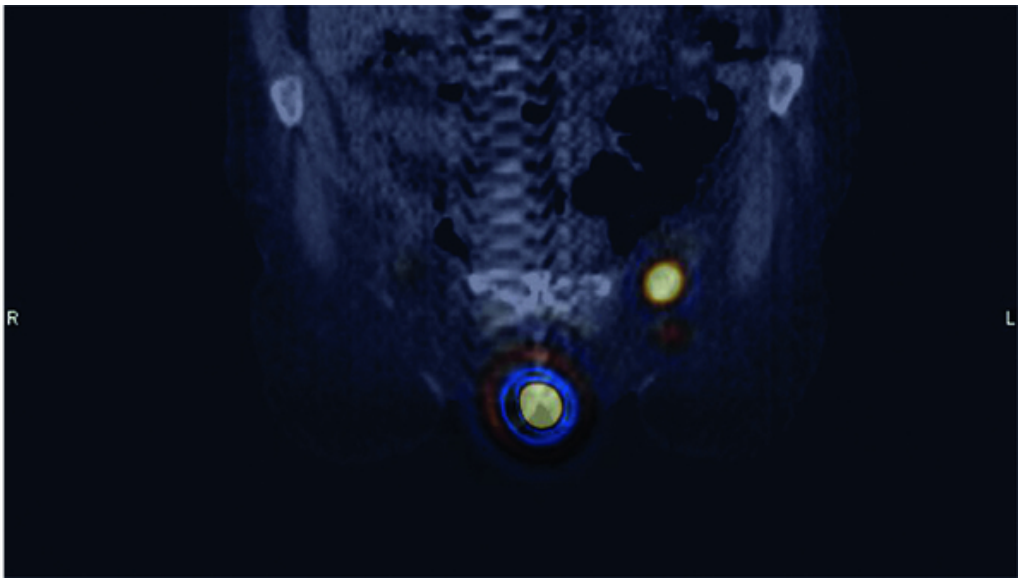
- Make incision 2 cm below inguinal ligament.
- Perform skin incision and incise Camper fascia.
- Create superior and inferior skin flaps.
- Identify the borders of the femoral triangle (adductor longus tendon, insertion of sartorius muscle, inguinal ligament).
- Dissect the superficial lymph node bundle.
- Identify the fossa ovalis and incise the fascia lata vertically.
- Dissect the deep lymph node bundle and Cloquet node from medial aspect of femoral vein.
- Achieve hemostasis.
- Place suction drains brought out through separate incision.
- Close subcutaneous layer and skin.

# Inguinofemoral Sentinel Lymph Node Mapping

Studies have established SLN mapping as the standard for groin lymph node evaluation in the appropriately selected patient. The criteria for performing SLN mapping may vary slightly between practice groups and institutions but generally include squamous histology, tumor size <4 cm, clinically and/or radiographically negative inguinofemoral lymph nodes, and a unifocal lesion.

Sentinel lymph node detection is most commonly performed using a dual-injection technique for lymphatic mapping using both technetium-99–labeled sulfur colloid and isosulfan blue dye. To identify the SLN, there must be coordination with nuclear medicine physicians and pathologists regarding the timing of the procedure and appropriate processing and analysis of the surgical specimens.

If the lymphadenectomy is to be performed as a morning procedure, the patient may be brought to nuclear medicine for an injection of 400 mCi of technetium-99–labeled sulfur colloid in the late afternoon/early evening the day prior. For an afternoon procedure, this injection may be done in the morning with 2-4 hours of time prior to the planned lymphadenectomy. After injection of technetium solution intradermally and circumferentially around the cancer, a technetium scan, lymphoscintigram, or single photon emission computed tomography is performed to confirm identification of an SLN and to identify whether there is an unexpected SLN drainage pattern. A member of the surgical team or a nuclear medicine specialist may do this injection, depending on institutional preference and/or difficulty of injection. The individual placing the injection should have training and familiarity with vulvar injection for SLN identification (**FIG. 26.13**; **BOX 26.5**).

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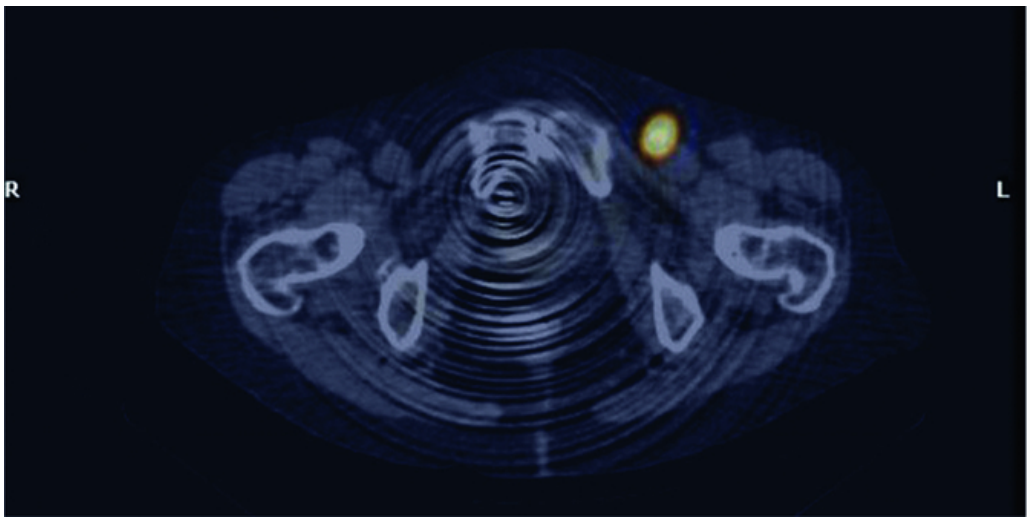



**FIGURE 26.13** SPECT/CT scan for detection of inguinal sentinel lymph node following injection of technetium-99–labeled sulfur colloid. **A.** Coronal view. The most inferior hot spot is the injection site, and hot node is on *right*. **B.** Transaxial view showing same hot node. (**A** and **B**: Courtesy of Ryan J Spencer, MD, MS, FACOG; University of Wisconsin School of Medicine and Public Health.)

## BOX 26.5 CRITERIA FOR PERFORMING SENTINEL LYMPH NODE BIOPSY

Unifocal tumors confined to the vulva

Tumors <4 cm in diameter

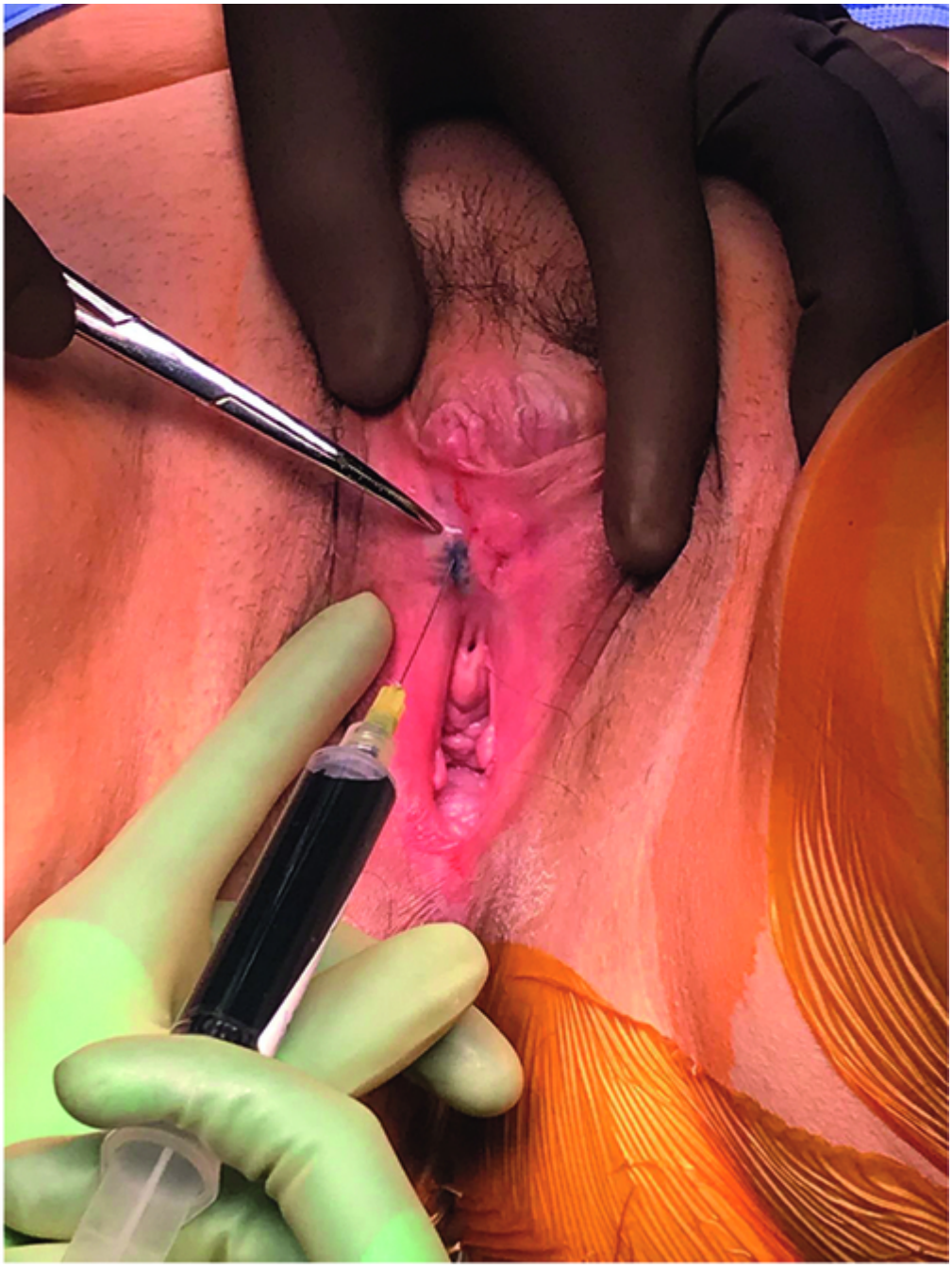
Squamous cell histology

Stromal invasion more than 1 mm

Clinically or radiologically nonsuspicious groin nodes

Adapted from GROINSS V trial 2008

In the operating room, the patient is placed in dorsal lithotomy position, and 1-2 mL of isosulfan blue dye is injected superficially around the periphery of the primary tumor in a similar manner to the prior technetium-99 injection. An intraoperative gamma probe with a sterile cover is activated. The background activity away from the patient is documented for comparison when evaluating the lymph node site(s). The patient's legs are lowered to the appropriate position as for a lymphadenectomy. Using the nuclear medicine imaging study, the gamma probe, and a knowledge of the anticipated location of inguinofemoral lymph nodes, an incision is made in a direction parallel and inferior to the inguinal ligament as described above for an inguinofemoral lymphadenectomy. The SLN approach has the advantage of typically using a much smaller incision than that utilized for a complete groin node dissection. As the subcutaneous layers are divided similar to a complete lymphadenectomy, the surgeon uses a combination of visual inspection to identify blue nodes and the gamma probe to identify radioactive or "hot" nodes (**FIG. 26.14**; **BOX 26.6**).



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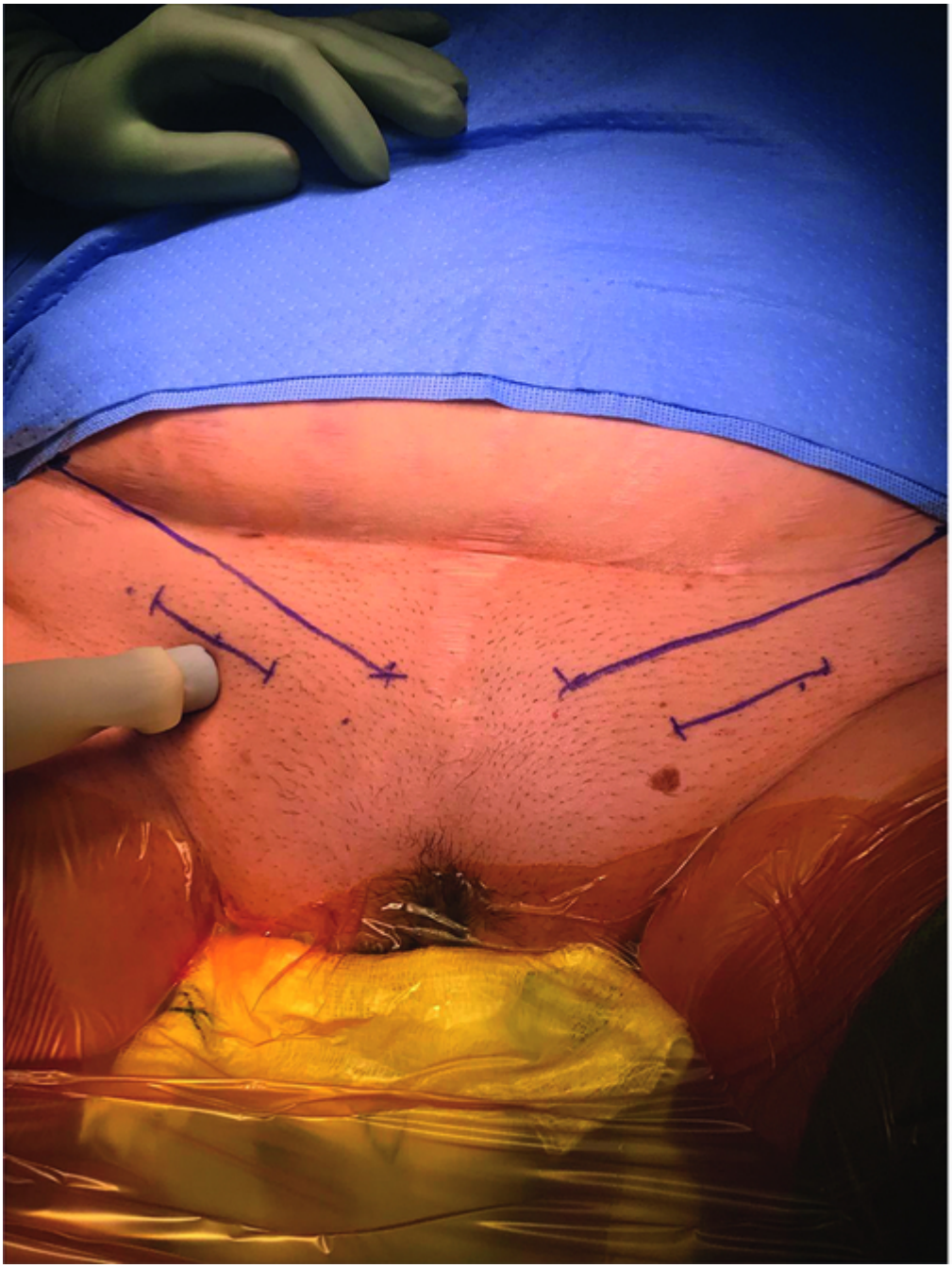

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**FIGURE 26.14** **A.** Vulvar injection of isosulfan blue dye. **B.** Intraoperative use of the gamma probe to identify optimal incision site for the radioactive sentinel node. The inguinal

ligament is marked and smaller incision will be performed for SLN dissection. (**A** and **B**: Courtesy of Ahmed Al-Niaimi, MD; University of Wisconsin School of Medicine and Public Health.) **C.** Intraoperative identification of isosulfan blue dye in a sentinel lymph node in the right groin.

## BOX 26.6 SENTINEL LYMPH NODE DISSECTION

- Preoperative injection of radiolabeled colloid and nuclear medicine imaging (at least 2-4 hours before surgery)
- Injection of isosulfan blue
- Skin incision(s)
- Identification of blue node(s) via direct visualization and "hot" node(s) with gamma probe
- Dissection and removal of sentinel nodes
- Achievement of hemostasis
- Placement of suction drains if applicable
- Subcutaneous and skin closure

# ULTRARADICAL SURGERY FOR VULVAR CANCER

Ultraradical surgery, including exenteration with inguinofemoral and pelvic lymphadenectomies, is occasionally performed for vulvar cancer, and more likely in the setting of recurrent disease. The need

for removal of the uterus, cervix, tubes and ovaries, the anterior compartment (bladder, urethra, anterior vagina, clitoris, anterior vulva, need for urinary conduit formation), and/or the posterior compartment (lower rectum, anus, posterior vagina, posterior vulva, perineum, need for permanent colostomy formation) should depend on lesion location and extent of invasion. In an era where effective neoadjuvant chemoradiation can effectively reduce the extent of surgery, the decision to perform extensive primary surgery should be undertaken with careful consideration. One study on the cumulative data for exenterative procedures for vulvar cancer showed a disease-free survival of 45% with a rate of perioperative mortality of ~5%.

# SURGERY FOR LESS COMMON VULVAR MALIGNANCIES

## Paget Disease of the Vulva

Extramammary Paget disease of the vulva is of apocrine origin (adenocarcinoma), generally confined to the epithelial layer, and can present as a small focus or can be extensive. Paget disease of the vulva is usually an *in situ* lesion; however, the reported incidence of invasive Paget's ranges from 7% to 25% of cases. Additionally, vulvar Paget's can be associated with an underlying malignancy at nonvulvar locations. Because of this, careful vulvar inspection and evaluation of other sites at risk for cancer are critical. Breast cancer is the most common coincident nonvulvar cancer, and mammography should be ordered if not recently performed. Depending on the subtype and lesion location, evaluation for other cancers may include CT scan of the abdomen/pelvis, pelvic ultrasound, cystoscopy, cervical cytology, endometrial sampling, vaginal examination, and anoscopy or colonoscopy (**FIG. 26.15**).

**FIGURE 26.15** Severe and extensive extramammary Paget disease of the vulva.

Biopsy for diagnosis should proceed as detailed previously for other vulvar lesions. The actual lesion may extend significantly beyond the visible lesion and may have occult multifocal areas. The disease may be extensive enough to require reconstruction for closure, and recurrence is observed in one-third of patients. Performing a simple vulvectomy with a 1-cm surgical margin is appropriate. For rare

cases of invasive disease, a modified radical vulvectomy with a 2-cm surgical margin and inguinofemoral lymphadenectomy is recommended as the incidence of lymph node metastasis has been reported to be as high as 30%.

For noninvasive disease, the goal of surgery is to obtain negative surgical margins. Some surgeons have used intraoperative frozen section for surgical margin assessment, and others have used injected fluorescein dye and Wood lamp with ultraviolet light to determine negative margins. Even with negative margins, recurrence is common (**FIGS. 26.16 and 26.17**).

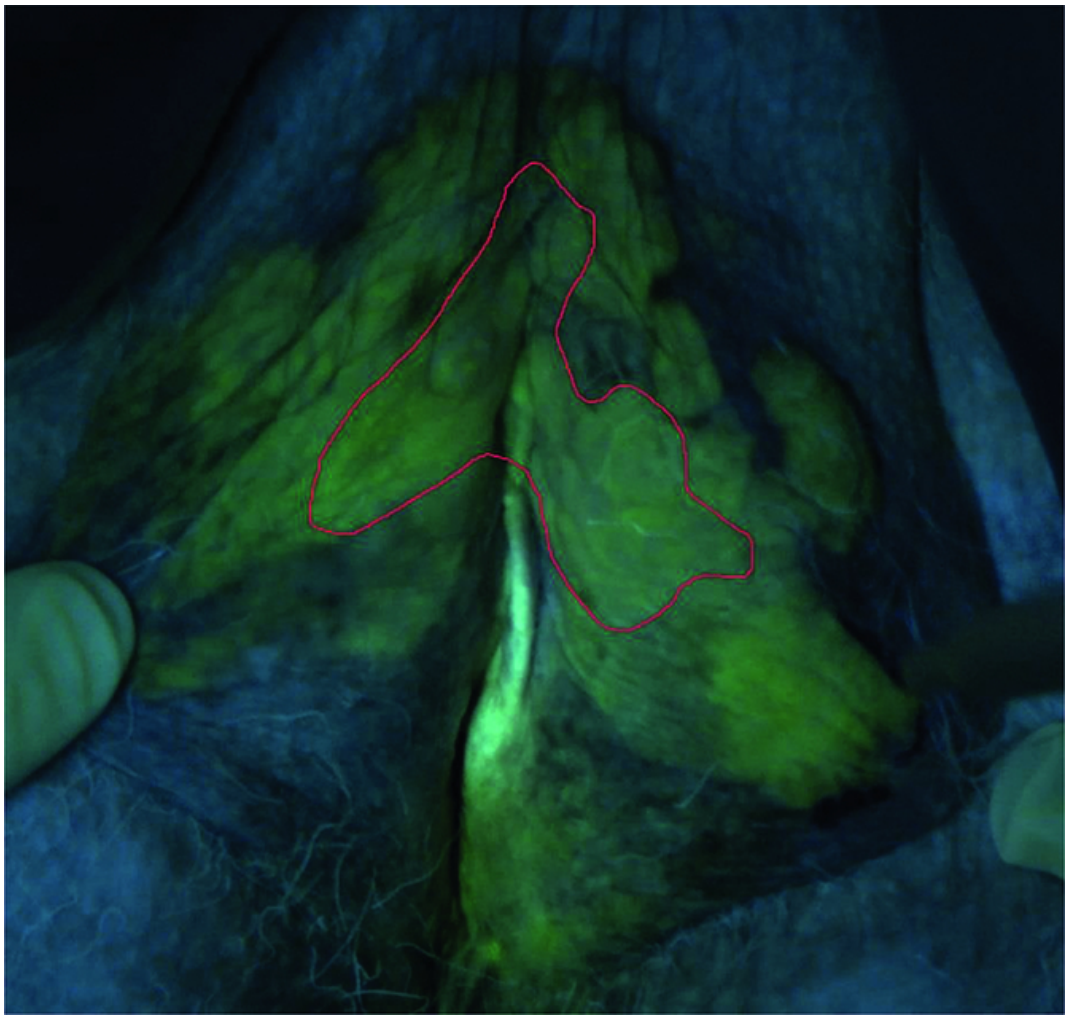


**FIGURE 26.16** Intraoperative inspection of extramammary Paget disease of the vulva

immediately following injection of IV fluorescein as seen under Wood lamp. The *red outline* demarcates the visible disease prior to the injection. (Courtesy of Ryan J Spencer, MD, MS, FACOG; University of Wisconsin School of Medicine and Public Health.)

**FIGURE 26.17** An example of mapping biopsies of the vulva for extramammary Paget disease of the vulva following the use of intraoperative fluorescein and Wood lamp. The largest *purple circle* represents the only

site of visible Paget's with the characteristic "red velvet" appearance. The three smaller *purple circles* represent areas visible only under fluorescein/Wood lamp that are visually normal but were positive for Paget disease on biopsy. The *red circle* represents a visually normal area that was visible only under fluorescein/Wood lamp that was positive for invasive Paget disease on biopsy. The *black circles* represent biopsies within the area visualized with fluorescein/Wood lamp and were negative for Paget's on biopsy. (Courtesy of Ryan J Spencer, MD, MS, FACOG; University of Wisconsin School of Medicine and Public Health.)

## Malignant Melanoma of the Vulva

Melanoma is the second most common vulvar cancer. The data for vulvar melanoma consist of case series, and management generally follows treatment standards for cutaneous melanoma of other sites. The Breslow scale measures the depth of melanoma invasion from the skin surface. This is measured in millimeters and is related to prognosis and outcome (**FIG. 26.18**).

**FIGURE 26.18** Vulvar melanoma.

The Gynecologic Cancer InterGroup published a consensus statement on the management of vulvar melanomas and included the following recommendations: a simple vulvectomy with 1-cm visual margin for the Breslow level of ≤2 mm, simple vulvectomy with a 2-cm visual margin for the Breslow level of >2 mm, SLN evaluation

for clinically node-negative patients, and lymphadenectomy for clinically node-positive patients. Performance of lymphadenectomy for cases of positive SLN continues to be a topic of debate. It should be noted that some argue against using SLN techniques until the benefit in vulvar malignant melanoma is better elucidated. Medical and surgical oncologists with expertise in the treatment of malignant melanoma should be incorporated into the treatment team.

## Bartholin Gland Carcinoma

A Bartholin gland carcinoma should be suspected with a mass found in the location of the Bartholin gland. Excision, or at the least, biopsy should be performed for women >40 years of age, anyone with a suspicious mass, or after previous benign biopsy of a Bartholin gland mass that does not respond to therapy for benign reasons such as infection.

In the absence of robust data, Bartholin gland cancers should be managed similarly to squamous cell carcinomas of the vulva. Modified radical vulvectomy is usually planned. However, these cancers tend to invade deeper structures and may require more extensive resections that can include portions of the vagina, perineal body, anal sphincter complex, anus, distal rectum, or levator muscles. Approximately 40% of these cancers will have metastatic lymph nodes, so inguinofemoral lymphadenectomy should be performed.

## Basal Cell Carcinoma

Basal cell carcinomas of the vulva are locally invasive and rarely spread to lymphatics. For this reason, resection of the primary lesion is appropriate unless there is clinical or radiographic suspicion of nodal metastasis. The radicality of the resection is determined by the surgeon based on specific tumor and patient characteristics. Partial simple vulvectomy may be adequate.

## Sarcomas

Vulvar sarcomas represent a heterogeneous group of cancers with distinct clinical presentations and natural histories. Some sarcomas (leiomyosarcoma, epithelioid sarcoma, malignant rhabdoid tumor, rhabdomyosarcoma) are more common than others (low-grade fibromyxoid sarcoma, synovial sarcoma, monophasic synovial sarcoma, carcinosarcoma, Ewing sarcoma, myeloid sarcoma, dermatofibrosarcoma protuberans, malignant fibrous histiocytoma, angiomatoid fibrous histiocytoma, liposarcoma, malignant peripheral nerve sheath tumor, malignant mesothelioma). Treatment should incorporate an interdisciplinary team that includes a radiation oncologist and a medical oncologist with expertise in sarcomas. While therapy for sarcomas is not well defined, radical excision is usually planned with neoadjuvant or adjuvant therapy.

## Verrucous Carcinoma

Verrucous carcinoma represents a clinically rare entity that is locally destructive and rarely metastasizes to lymph nodes. Modified radical vulvectomy without inguinofemoral lymphadenectomy is most often performed. Partial simple vulvectomy has also been described in the literature. When there is suspicion of metastases to groin lymph nodes, lymphadenectomy should be strongly considered.

# RECONSTRUCTION

Most vulvar resections can be closed primarily. Some resections may require preoperative planning for reconstruction due to the size of the resection, location, patient tissue volume, desire for creation of a neovagina, prior radiation treatment, or medical comorbid conditions (eg, hypertension, smoking, diabetes, disorders of fibroelastic tissue). A critical part of the preoperative evaluation is planning for surgical closure. Given the outcomes and complication rates of many contemporary surgical procedures, consultation with a reconstructive surgeon is generally recommended if a complicated closure is anticipated. When vulvar or vaginal reconstruction is required, skin grafts from a donor site, local advancement flaps, and fasciocutaneous or myocutaneous flaps from the leg or the

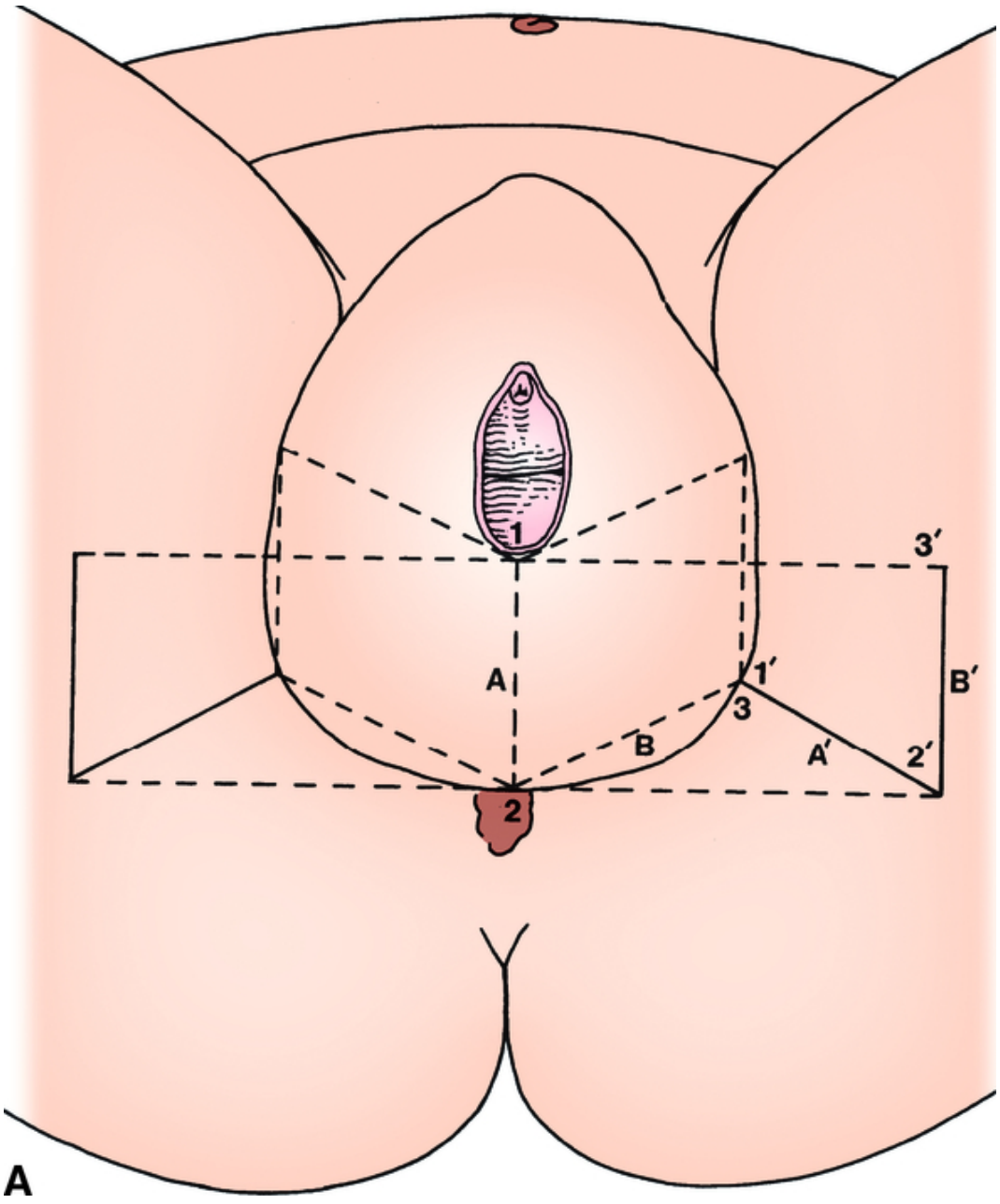
abdominal wall may be used. Skin grafts rely on recipient site blood supply, whereas flaps rely on donor site blood supply.

## Skin Grafts

Skin grafts may be split thickness and contain the epidermis with some degree of the dermis, or full thickness and contain all skin layers. The selection of graft type is based on size and location of the defect as well as the identification of an appropriate donor site. Skin grafts may be appropriate with robust recipient site blood supply but are avoided if the recipient site is devascularized as may be the case after prior radiation therapy.

## Flaps for Reconstruction

Local full-thickness skin flaps mobilize or rotate skin with underlying subcutaneous tissues and bring either a random blood supply (eg, Limberg rhomboid flap, V-Y advancement flap) or a planned blood supply (eg, labial flaps). Random flaps should not have a length any greater than twice the base width to avoid flap loss. The Limberg (rhomboid) flap is used on many parts of the body and may be particularly useful when reconstructing a perineal body after either total vulvectomy or a posterior modified radical vulvectomy. Flaps with a known and planned blood supply are technically more difficult to create and transplant with preservation of the blood supply (**FIG. 26.19A-C**).

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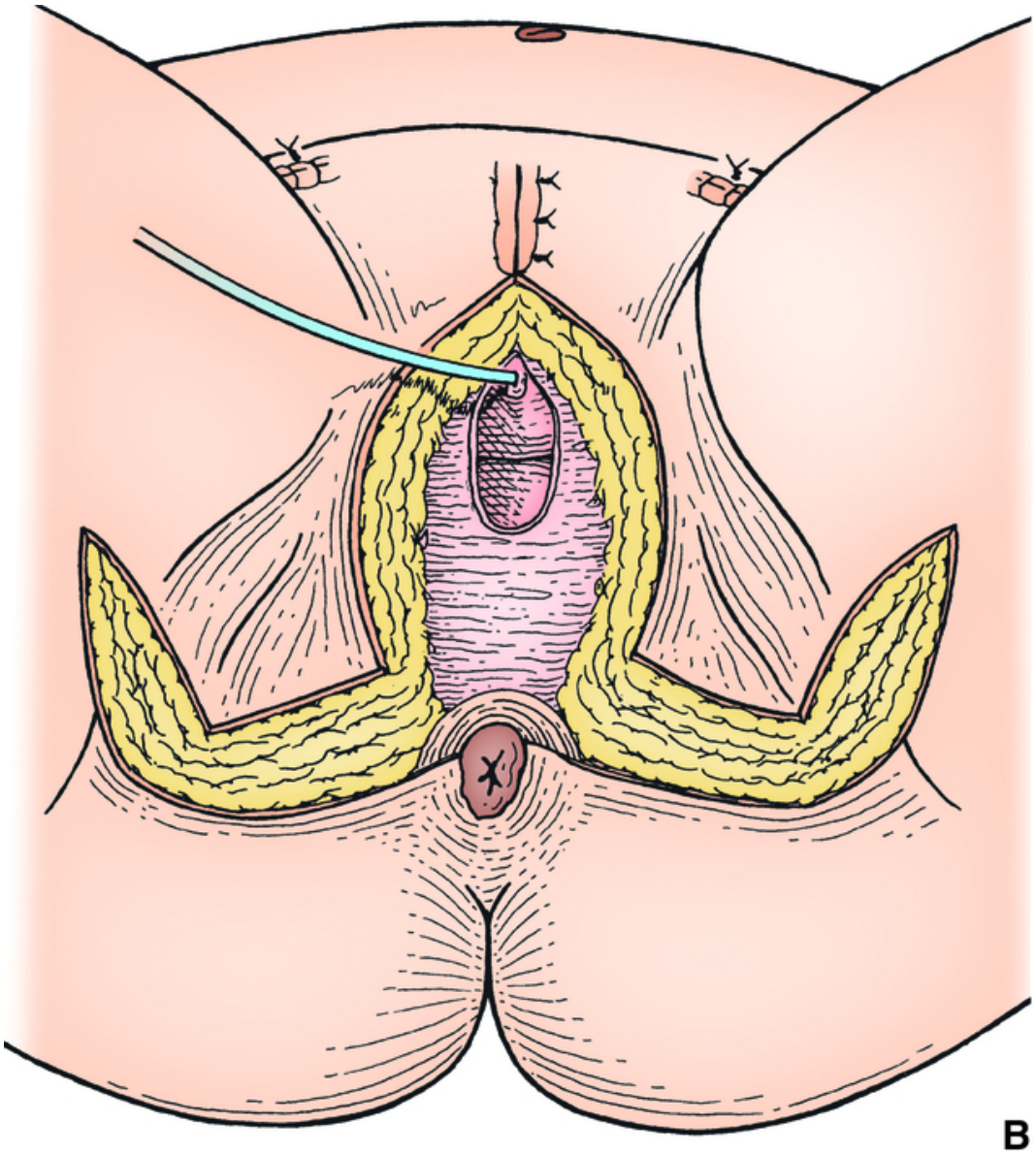

B

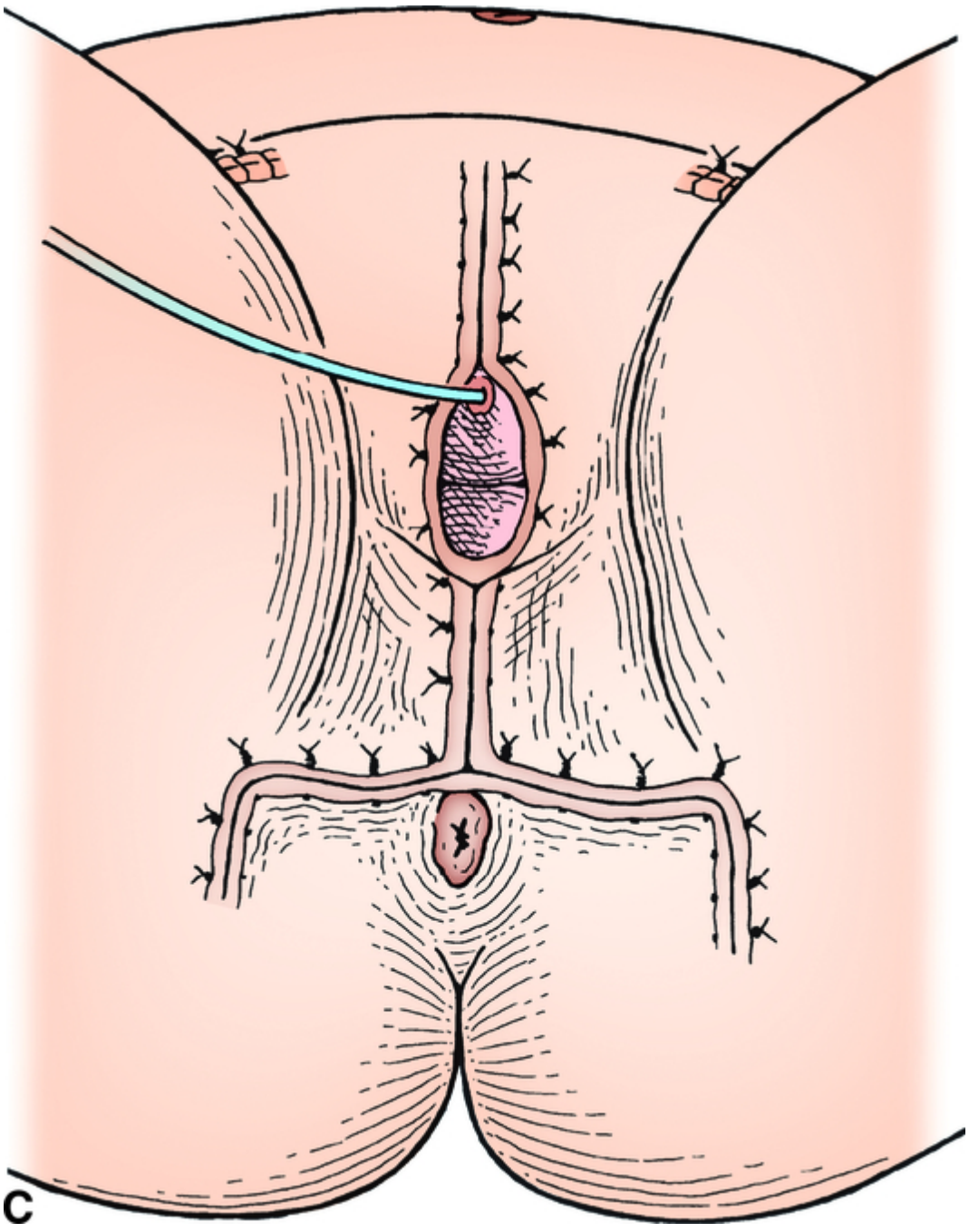


**FIGURE 26.19** **A.** Planning the rhomboid flap. The defect is divided into two rhomboids. Measurements *A* and *B* are made and marked on the skin of the thigh (*A′* and *B′*). After the flap is mobilized, *1′* will be located at the

posterior vaginal introitus (*1*) and *2′* at the anterior anus and 3’ will go to position 3 (*2*). **B.** The bilateral rhomboid flaps are developed. **C.** The flaps have been rotated, and the posterior perineal defect is closed.

Fasciocutaneous flaps containing skin, subcutaneous tissues, and fascia layer(s) (eg, pudendal thigh flap, anterolateral thigh flap, medial thigh flap) are more reliable as they contain additional vasculature that perforates through the fascial plane. These flaps may be particularly useful for larger but more superficial defects.

Myocutaneous flaps include skin, subcutaneous tissues, fascia, and underlying musculature that have a defined and specific blood supply. These vessels must be identified with precision and moved into position in a way that avoids twisting of the vasculature on its pedicle. Myocutaneous flaps are bulkier and applied to larger, deeper defects such as those encountered after a total pelvic exenteration or for reconstruction in previously irradiated tissue. The rectus abdominis myocutaneous flap is often used during an exenteration either to fill a perineal defect or to create a neovagina.

## KEY POINTS

- High-grade dysplasia of the vagina and vulva can harbor underlying malignancies, and surgical therapy should be strongly considered for both diagnosis and treatment to prevent progression to cancer.
- For preinvasive disease, negative margins correlate with reduced risk for recurrence.
- Careful consideration of incision closure is a critical part of preoperative planning for vulvar surgery.

- Surgical care of vulvar cancer involves operative considerations for both the vulvar phase of the procedure and for inguinofemoral lymph node evaluation.
- Sentinel lymph node dissection for vulvar cancer is performed through a smaller incision and is associated with fewer complications. All patients should be evaluated for an SLN approach.

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# CHAPTER 27

# SURGERY FOR UTERINE CANCER

Edward Tanner

**Staging**
**Prognostic Features**
**Endometrial Hyperplasia**
**Surgery for Endometrial Cancer**
Perioperative Assessment and Preparation
Hysterectomy
Lymphadenectomy
Minimally Invasive Hysterectomy
Minimally Invasive Lymphadenectomy
Sentinel Lymph Node Mapping
**Special Clinical Scenarios**
Surgery for the Morbidly Obese Patient
Management of Advanced Disease
Surgery for Young Patients
**Surgery for Type II Endometrial Cancers**
**Surgery for Uterine Sarcomas**
**Lynch Syndrome**
**Undiagnosed Endometrial Cancers**

Endometrial cancer is the most common gynecologic cancer in the United States. The American Cancer Society estimates that there will be 65 950 cases with 12 550 deaths in 2022. Most patients with endometrial cancer have a good prognosis and are often treated with surgery alone. Patients diagnosed with high-grade histology or advanced-stage disease will have a high risk of mortality even with the addition of chemotherapy or radiation after surgery. Advancements in surgical staging, such as the introduction of sentinel lymph node (SLN) mapping, allows complete staging information with reduced morbidity.

The traditional prognostic framework for endometrial cancer divides patients into two groups with distinct survival outcomes based on histology. Type I tumors account for the majority (70%) of all endometrial cancers and have an excellent prognosis, especially when confined to the uterus at the time of diagnosis. These tumors have low-grade endometrioid histology and are usually diagnosed at an early stage. In many cases, these tumors are associated with unopposed estrogen exposure often related to obesity. Type II tumors account for the remaining 30% of endometrial cancers and have inferior prognosis compared to type I tumors. Type II tumors include serous, clear cell, carcinosarcoma, and high-grade endometrioid histology (grade 3) and often present with advanced-stage disease at diagnosis. For many type II tumors, risk factors for tumorigenesis have not been identified.

Type I and type II tumors arise through different molecular pathways. Type I tumors are more likely to exhibit microsatellite instability (MSI) as well as aberrant function of *PTEN, PIK3CA, KRAS, ARID1A*, and *CTNNB1* genes. Type II serous tumors are more likely to exhibit inactivation mutations of p53 and HER2 amplification.

While histology and grade remain an important framework for guiding prognosis and treatment, results from The Cancer Genome Atlas (TCGA) have led to new prognostic criteria based on genomic characteristics. These subgroups will guide treatment decisions in the future. The prognostic genetic subgroups include POLE-ultra mutated, MSI-hypermutated, copy-number (CN)-low, and CN-high.

POLE-mutated tumors are particularly intriguing, as these tumors often have type II histology but a better outcome than would otherwise be expected based on histology alone. The Proactive Molecular Risk Classifier for Endometrial Cancer (ProMisE) is a decision-tree system based on TCGA findings that has potential to determine cancer prognosis and treatment. (**FIG. 27.1**).

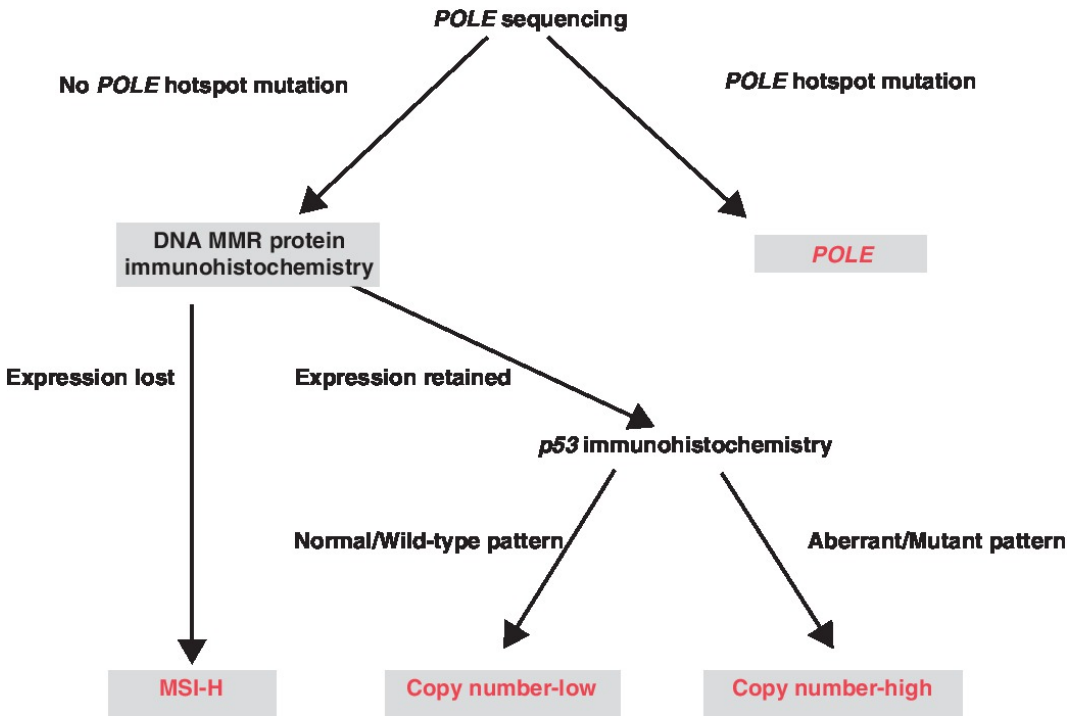


**FIGURE 27.1** ProMisE algorithm. *POLE*, DNA polymerase epsilon; mut, mutation; MMR, mismatch repair; IHC, immunohistochemistry; MMRd, mismatch repair deficient; NSMP, no specific molecular profile; wt, wild type; abn, abnormal expression; EC, endometrial carcinoma. (Based on Talhouk A, McConechy MK, Leung S, et al. A clinically applicable molecular-based classification for endometrial cancers. *Br J Cancer*. 2015;113(2):299-310)

Endometrial cancer staging is ideally treated surgically. Patients treated with radiation or hormonal therapy instead of surgery due to medical comorbidities have poor long-term disease control and may suffer from persistent symptomatic bleeding. Hysterectomy should be performed unless there is a significant contraindication. Minimally invasive surgery has emerged as a preferred surgical approach for most patients. Adjuvant therapy for patients with metastatic disease has gradually transitioned from radiation to systemic chemotherapy. Radiation remains an important adjuvant treatment to reduce the risk of local/pelvic recurrence in high-risk patients. Overall, changes to the treatment paradigm have resulted in improved quality of life for many patients and improved survival.

# STAGING

The FIGO surgical staging system for endometrial cancer was last updated in 2009 (**TABLE 27.1**). The most significant changes to FIGO staging occurred for patients with stage III disease. The presence of positive peritoneal cytology was removed from the guidelines due to a lack of prognostic value, especially in otherwise low-risk patients. Cytologic evaluation of peritoneal washings is no longer part of staging; however, the National Comprehensive Cancer Network (NCCN) still recommends their inclusion as part of surgical staging, especially for patients with type II tumors where cytology status can influence the decision to omit chemotherapy in patients with noninvasive tumors. Collection of peritoneal washings is otherwise left to the surgeon's discretion. In consideration of the inferior survival of patients with paraaortic nodal metastases compared to only pelvic lymph node metastasis, stage IIIC has been further subdivided into stage IIIC1 (pelvic lymph node metastasis) and stage IIIC2 (paraaortic lymph node metastasis) (**TABLE 27.2**; **FIG. 27.2**).

## TABLE 27.1
## FIGO Staging of Carcinoma of the Corpus Uteri,

# 2009

| | |
|---|---|
| Stage I | Tumor confined to the corpus uteri |
| IA | No or less than half myometrial invasion |
| IB | Invasion equal to or more than half of the myometrium |
| Stage II | Tumor invades cervical stroma but does not extend beyond the uterus |
| Stage III | Local and/or regional spread of tumor |
| IIIA | Tumor invades the serosa of the corpus uteri and/or adnexa |
| IIIB | Vaginal and/or parametrial involvement |
| IIIC | Metastases to pelvic and/or paraaortic lymph nodes |
| IIIC1 | Positive pelvic lymph nodes |
| IIIC2 | Positive paraaortic lymph nodes with or without positive pelvic lymph nodes |
| Stage IV | Tumor invades bladder and/or bowel mucosa and/or distant metastases |
| IVA | Tumor invasion of bladder and/or bowel mucosa |
| IVB | Distant metastases, including intra-abdominal metastases and/or inguinal lymph nodes |
| Positive cytology has to be reported separately without changing the stage | |
| Histopathology: degree of differentiation | |
| Grade 1 | 5% or less of a solid growth pattern |
| Grade 2 | 6%-50% of a solid growth pattern |
| Grade 3 | More than 50% of a solid growth pattern |
| Notable nuclear atypia, inappropriate for the architectural grade, raises the grade of a grade 1 or grade 2 tumor by 1 | |
| Uterine papillary serous carcinomas and clear cell carcinomas of the endometrium are always high-grade tumors, by definition | |

## TABLE 27.2
## Endometrial Cancer Histology

| | |
|---|---|
| Endometrioid adenocarcinoma | 80% |
| Serous adenocarcinoma | 10% |
| Clear cell adenocarcinoma | <5% |
| Carcinosarcoma/other | <5% |

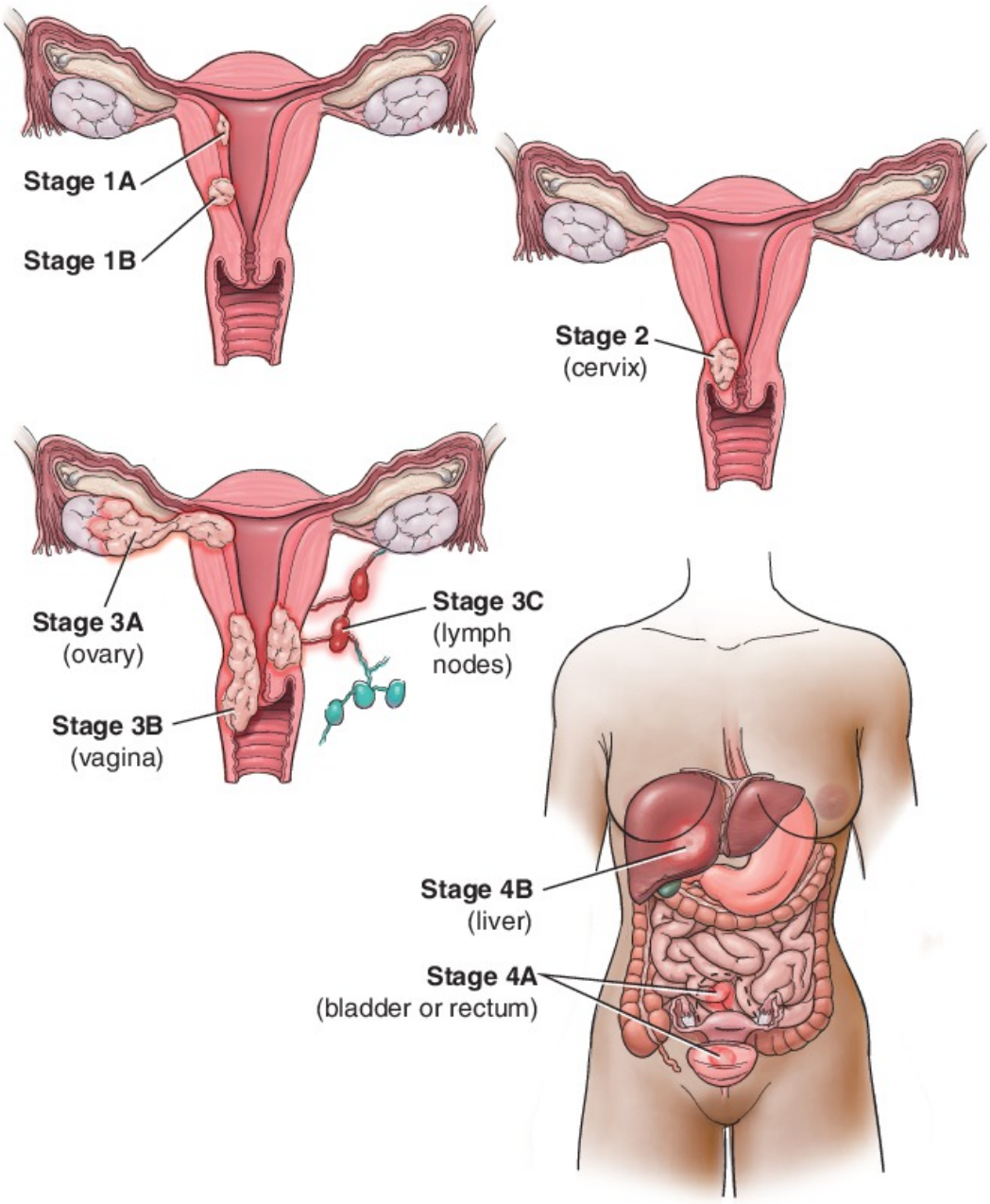


**FIGURE 27.2** Surgical stages of endometrial cancer.

Uterine sarcomas were separated from other uterine neoplasms in the FIGO 2009 staging update considering the distinctive dissimilar pattern of spread when compared to endometrioid carcinomas. Uterine sarcomas include leiomyosarcoma, endometrial stromal

sarcoma, adenosarcoma, and undifferentiated sarcoma. Carcinosarcomas, also known as malignant mixed müllerian tumors and previously categorized as sarcomas, are now considered with endometrial cancers due to similarities in patterns of spread and molecular characteristics (**TABLE 27.3**).

## TABLE 27.3
## FIGO Staging of Uterine Sarcomas, 2009

**Leiomyosarcomas and ESS**[a]

Stage definition

| | |
|---|---|
| I | Tumor limited to uterus |
| | IA ≤ 5 cm |
| | IB > 5 cm |
| II | Tumor extends beyond the uterus, within the pelvis |
| | IIA Adnexal involvement |
| | IIB Involvement of other pelvic tissues |
| III | Tumor invades abdominal tissues (not just protruding into the abdomen) |
| | IIIA 1 site |
| | IIIB > 1 site |
| | IIIC Metastases to pelvic and/or paraaortic lymph nodes |
| IV | Tumor with |
| | IVA Bladder and/or rectum invasion |
| | IVB Distant metastases |

**Adenosarcomas**

Stage definition

| | |
|---|---|
| I | Tumor limited to uterus |
| | IA Tumor limited to endometrium/endocervix with no myometrial invasion |
| | IB ≤ half myometrial invasion |
| | IC > half myometrial invasion |
| II | Tumor extends beyond the uterus, within the pelvis |
| | IIA Adnexal involvement |
| | IIB Involvement of other pelvic tissues |
| III | Tumor invades abdominal tissues (not just protruding into the abdomen) |
| | IIIA 1 site |
| | IIIB > 1 site |
| | IIIC Metastases to pelvic and/or paraaortic lymph nodes |
| IV | Tumor with |
| | IVA Bladder and/or rectum invasion |
| | IVB Distant metastases |

*Carcinosarcomas should be staged as carcinomas of the endometrium*

[a]*Note*: Simultaneous endometrial stromal sarcomas of the uterine corpus and ovary/pelvis in association with ovarian/pelvic endometriosis should be classified as independent primary tumors.

# PROGNOSTIC FEATURES

The prognostic features of endometrial cancer are well established (**TABLE 27.4**). Histology, tumor grade, depth of myometrial invasion, cervical stromal invasion, lymph node, and distant metastases impact prognosis. Other features, such as age, and presence of lymphovascular space invasion are also important prognostic factors.

## TABLE 27.4
## Prognostic Features for Endometrial Cancer

| |
|---|
| FIGO stage |
| Depth of myometrial invasion[a] |
| Tumor grade[a] |
| Histologic subtype[a] |
| Cervical involvement |
| Adnexal involvement |
| Positive pelvic washings |
| Metastases to the pelvic or paraaortic lymph nodes |
| Lymphovascular space invasion |
| DNA aneuploidy |

[a]Denotes prognostic features that are most important in patients with endometrial cancers confined to the uterus.

Patients with stage I disease, older age, and a combination of three uterine-based risk factors (tumor grade 2 or 3, deep myometrial invasion, and the presence of lymphovascular space invasion) constitute a subgroup of patients at “high intermediate risk” for recurrence; these patients may benefit from surgical staging and/or

adjuvant therapy. In the Gynecologic Oncology Group (GOG) trial reported by Keys et al., high intermediate risk was defined as patients (1) at any age with three risk factors; (2) age ≥50 but <70 with at least two risk factors; or (3) age ≥70 with at least one risk factor. Postoperative therapies are tailored based on these risk factors.

# ENDOMETRIAL HYPERPLASIA

Endometrial hyperplasia is characterized by excessive proliferation of the endometrial lining. In many cases, hyperplasia arises because of excess or unopposed estrogen exposure. In 1985, Kurman characterized hyperplasia as simple hyperplasia (SH) with or without atypia and complex hyperplasia (CH) with or without atypia. The original study noted that 1% of patients with SH, 3% of patients with CH, 8% of patients with SH with atypia, and 29% of patients with CH and atypia progressed to cancer. Simple hyperplasia demonstrates increased numbers of glands with little crowding while complex hyperplasia demonstrates glandular crowding or budding and irregular borders. Complex hyperplasia with atypia is characterized by atypical cellular changes, including enlarged nuclei, increased mitotic activity, and loss of nuclear polarity. Mutter et al. (2000) subsequently characterized premalignant endometrial lesions as endometrial intraepithelial neoplasia (EIN) using a semiquantitative morphometric analysis that distinguishes EIN from lower-risk lesions designated as benign endometrial hyperplasia. This two-tier system appears to be more reproducible and predictive of malignancy but is not yet universally adopted. According to the WHO (2014), “Cytological atypia superimposed on endometrial hyperplasia defines atypical hyperplasia (AH)/endometrial intraepithelial neoplasia (EIN).” In both classification systems, the risk of malignancy increases as lesions become more complex and atypia is present.

Hysterectomy is the preferred treatment for patients with CAH/EIN who are surgical candidates and do not wish to retain fertility. A minimally invasive approach is preferred over abdominal hysterectomy. Vaginal hysterectomy is a reasonable approach if lymph node assessment is not planned; this route should be

considered for patients who are too ill to undergo general anesthesia but are poor candidates for hormonal treatment. Given the risk of malignancy, supracervical hysterectomy and morcellation are not acceptable procedures. In postmenopausal patients, oophorectomy is recommended, whereas in premenopausal women, ovarian preservation is an option.

Invasive carcinoma will be identified in 40%-50% of CAH patients undergoing hysterectomy. Although the majority of these patients will have a low-risk cancer, a small percentage will have high-risk features necessitating lymphatic assessment. In a study by Vetter and colleagues, 49% of patients with EIN on preoperative sampling had invasive carcinoma on final pathology. Of these patients, 13% had high-risk uterine features including high-grade histology, large tumors, or >50% myometrial invasion. Endometrial thickness on preoperative ultrasound appears to correlate with high-risk features at time of hysterectomy as 44% of patients with a stripe of at least 2 cm had high risk uterine features.

Patients with a preoperative diagnosis of EIN could consider frozen section of the uterus at the time of hysterectomy to determine the need for lymphadenectomy. Patients with EIN who undergo hysterectomy without a gynecologic oncologist available to perform immediate lymphadenectomy can undergo surgical staging as a second procedure if high-risk features are identified on final pathology. Given the potential need for lymphadenectomy at the time of initial surgery, preoperative referral to a gynecologic oncologist should be considered.

For patients with EIN or low-grade endometrial cancer who wish to retain fertility, conservative treatment with progestin therapy can be offered. The National Comprehensive Cancer Network guidelines list progestin therapy as an option, which includes high-dose oral agents such as megestrol acetate (40-200 mg daily), medroxyprogesterone acetate (10-20 mg daily), and the levonorgestrel-containing IUD system. Levonorgestrel IUD results in equivalent if not superior response rates to oral progestins with less weight gain and should be considered as a preferred regimen for most patients.

When managed without surgery, endometrial sampling is performed every 3-6 months until resolution, and if progression is noted, proceed to hysterectomy. In a prospective trial of 57 women with EIN or grade 1 endometrial cancer desiring future fertility, 81% of EIN patients and 38% of endometrial cancer patients achieved a complete response to levonorgestrel IUD at 12 months. Although many patients will respond to treatment, at least one-third will recur within a few years of treatment. With uterine conservation, more than one-third of patients achieved a live birth following successful completion of therapy (**TABLE 27.5**).

## TABLE 27.5
## Hormonal Therapy for Endometrial Intraepithelial Neoplasia[a]

| HORMONAL AGENT | DOSAGE AND LENGTH |
|---|---|
| Medroxyprogesterone acetate | 10-20 mg/d, or cyclic 12-14 d/mo |
| Depot medroxyprogesterone | 150 mg intramuscularly, every 3 mo |
| Micronized vaginal progesterone | 100-200 mg/d or cyclic 12-14 d/mo |
| Megestrol acetate | 40-200 mg/d |
| Levonorgestrel intrauterine system | 52 mg in a steroid reservoir over 5 y |

[a]Previously known as atypical endometrial hyperplasia.

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Prior to initiating progestin therapy, patients must undergo a thorough evaluation and counseling. This includes a D&C if only an office biopsy was initially performed to confirm low-risk histology. For reproductive age patients a fertility evaluation should be performed to exclude other factors that would preclude a successful pregnancy. Patients with invasive carcinoma for whom surgery is not planned should also undergo an MRI to assess myometrial invasion and nodal metastasis. Patients should be thoroughly counseled about the small risk of disease progression during conservative therapy and must weigh this risk against fertility goals, especially if treatment has been unsuccessful after a year. Obese patients are counseled about the importance of weight loss and should be referred to a weight loss program and for evaluation for bariatric weight loss surgery.

# SURGERY FOR ENDOMETRIAL CANCER

Hysterectomy is definitive treatment for endometrial cancer. With the addition of surgical staging, the extent of disease, prognosis, and postoperative treatment plan can be established. Surgical staging should include assessment of the peritoneal cavity. Patients who are postmenopausal, have type II tumors, or have metastatic disease should also undergo bilateral salpingo-oophorectomy. Young patients with type I tumors can consider ovarian preservation if ovaries are observed to be grossly normal; however, a discussion should include disclosure that the ovary is a potential site of metastasis. The extent and approach of pelvic and paraaortic lymph node assessment has changed significantly over the last 10 years. Sentinel lymph node (SLN) mapping has emerged as a new standard of care for lymphatic assessment. A minimally invasive approach is now preferred whenever feasible and safe.

The approach to surgical staging of endometrial cancer is based on the pattern of spread—which differs for type I and type II tumors. Type I tumors initially spread by direct extension into the myometrium and then to adjacent structures, such as lymph nodes, cervix, adnexa, or parametria. Distant metastasis to the lung, liver, or

peritoneal cavity usually occurs late in this process or in the setting of recurrent disease. Lymphatic spread remains the most important factor for both prognosis and tailoring adjuvant therapy. Tumor grade, depth of myometrial invasion, tumor diameter, and the presence of lymphovascular space invasion are associated with increased risk of metastatic disease to nodal tissue.

There are several strategies to assess the presence of spread to nodal areas. Surgeons may choose to perform a full pelvic lymphadenectomy with or without paraaortic lymphadenectomy for all patients with type I tumors, recognizing that the vast majority of patients will have negative lymph nodes and will be overtreated with this approach. Lymphadenectomy results in symptomatic lower extremity lymphedema in ~22% of patients during the first 2 years after surgery. Alternatively, and to reduce this risk, surgeons may omit lymphadenectomy and await final pathology results to determine the need to a return to the operating room for lymphadenectomy. As a third option, surgeons may consider obtaining intraoperative frozen section with assessment of high-risk factors to determine the need for lymph node dissection. Finally, SLN mapping can be considered, as will be discussed.

Type II tumors spread through the mechanisms outlined above but may also spread to the peritoneal cavity in a similar fashion to ovarian cancer, especially when serous histology is identified. These tumors are more likely to spread to the peritoneum or distant sites even when the primary tumor is small or shows minimal myometrial invasion. As such, all patients with type II tumors should undergo lymphatic assessment regardless of uterine features. SLN mapping appears to have similar accuracy for lymphatic assessment with type II tumors as with type I tumors. Patients with type II tumors should also undergo omental biopsy as the risk of occult omental spread is between 5% and 25%.

Peritoneal washings are performed at the discretion of the surgeon at the time of endometrial cancer surgery. Obtaining washings is not required for surgical staging. Transtubal dissemination of tumor cells occurs frequently in patients who have undergone diagnostic hysteroscopy and/or uterine manipulator placement. However, in this setting, peritoneal dissemination of

tumor cells has not been shown to clearly result in negative outcomes. In a meta-analysis by Wethington et al., peritoneal washings demonstrating malignant cells were not independently associated with recurrence risk in patients with otherwise low-risk disease. For patients with high-risk disease, such as type II tumors or patients with other evidence of regional metastasis, positive cytology may still retain prognostic significance.

## Perioperative Assessment and Preparation

Given the association between obesity and endometrial cancer, many patients will have other comorbidities that impact their surgical outcome. Cardiovascular disease, morbid obesity, sleep apnea, and diabetes occur frequently in patients with endometrial cancer. These conditions should be identified and optimized prior to surgery to reduce the risk of perioperative morbidity. In addition to ruling out concurrent conditions, patients should be assessed for signs and symptoms of metastatic disease. Symptoms such as abdominal pain, change in bowel or bladder habits, lower extremity edema, bloating, early satiety, cough, and shortness of breath should prompt further evaluation. Patients with type I tumors do not require preoperative imaging unless symptoms or examination raise the level of suspicion. In morbidly obese patients, uterine size can be difficult to assess. Ultrasound imaging will determine uterine size and whether vaginal extraction at the time of minimally invasive surgery should be planned. Patients with type II tumors should undergo imaging of the chest, abdomen, and pelvis prior to surgery, as should patients with worrisome symptoms or examination findings. Serum CA125 levels can be ordered for patients with serous histology. Finally, patients should be queried about their family cancer history to assess their risk for Lynch syndrome.

Prophylaxis with sequential compression devices and 5000 units of subcutaneous heparin are administered prior to induction of anesthesia to prevent venous thromboembolism. This will not significantly increase the risk of intraoperative bleeding. Bowel

preparation is no longer indicated for endometrial cancer staging. In many cases, the unprepped colon may be easier to manipulate with the added advantage of avoiding intraoperative volume depletion due to bowel preparation–induced dehydration. Prior to incision, patients should undergo appropriate weight-based antibiotic prophylaxis. Implementation of enhanced recovery pathways has been shown to reduce postoperative complications, decrease the length of hospitalization, and hasten the return of bowel function following surgery.

# Hysterectomy

Unless cervical invasion is suspected, patients with endometrial cancer should undergo extrafascial hysterectomy, preferably with a minimally invasive approach. An abdominal approach is reserved for patients with a medical contraindication to laparoscopy (eg, severe pulmonary insufficiency precluding insufflation), a uterus too large to be removed intact through the vagina, an extensive surgical history that precludes safe laparoscopy, or evidence of peritoneal metastatic disease on preoperative imaging.

If hysterectomy is performed by laparotomy, the surgeon should carefully evaluate the peritoneal surfaces, omentum, and diaphragms for evidence of peritoneal spread upon entry into the abdominal cavity. Peritoneal washings may be obtained despite the uncertain prognostic significance associated with positive cytology; these are obtained based on surgeon preference. Upon completion of the peritoneal assessment, placement of retractor, and clearing the surgical field, the pelvic sidewalls are opened parallel to the gonadal vessels. The round ligaments should be divided at the pelvic sidewall rather than closer to the uterus to facilitate pelvic lymphadenectomy. If SLN mapping is not performed, the pararectal space is developed and the ureters are identified. Direct identification of the ureters in the retroperitoneal space, rather than visualizing these transperitoneally through the posterior leaf of the broad ligament, will reduce the likelihood of an unrecognized ureteral injury later in the procedure. When removing the ovaries, the infundibulopelvic ligaments should be divided 2 cm proximal to the

margin of the normal ovary to reduce risk of leaving an ovarian remnant. If the ovaries are to be retained, opportunistic salpingectomy should be performed to reduce fallopian tube cancer risk. The ovaries are closely inspected for evidence of metastasis.

Once the anterior leaf of the broad ligament is divided and the vesicouterine space is developed, the uterine arteries are skeletonized and ligated. When ligating the uterine vessels and cardinal ligaments, clamps should be placed on the lateral border of the uterus and cervix rather than rolling off the corpus, as this will ensure an extrafascial resection. A similar process should be carried out when placing clamps across the uterosacral ligaments and cervicovaginal junction during the final steps of specimen excision. Upon completion of the colpotomy, both the resected cervix and vaginal margins should be inspected to ensure complete cervical resection. If in doubt, a small additional vaginal margin can be resected. A sponge stick or vaginal probe can be inserted into the vaginal to better delineate the cervico-vaginal junction and ensure complete resection of the cervix. Surgeons should also avoid transecting the fundus from the cervix during the procedure as this risks spilling tumor into the peritoneal cavity. Vaginal cuff closure can be performed according to surgeon preference (**FIG. 27.3**) (**VIDEOS 27.1** and **27.2**).

**FIGURE 27.3** Open uterus with endometrial cancer.

## Lymphadenectomy

The role and extent of lymphadenectomy for patients with endometrial cancer has changed significantly over the last decade. SLN mapping techniques will be discussed later in this chapter, as will the role of completion lymphadenectomy following failed bilateral SLN mapping. If SLN mapping is not utilized, lymphatic assessment strategies largely depend upon tumor type. For patients with type II tumors not undergoing SLN mapping, complete pelvic and paraaortic lymphadenectomy remains the standard approach.

For patients with type I tumors undergoing hysterectomy, frozen section of the uterus may be performed to determine the need for lymphadenectomy. This relies upon the correlation between high-risk uterine features and lymphatic metastasis in low-grade tumors. After removing the uterus, the specimen is sent to pathology to determine tumor diameter, depth of myometrial invasion, and tumor grade. Mariani and colleagues demonstrated a 5% risk of nodal metastasis in patients with grade 1 or 2 tumors <2 cm in diameter with <50% invasion. Subsequent studies have demonstrated excellent long-term outcomes in patients meeting these “Mayo criteria” and who did not undergo lymphadenectomy. Using this approach, the rate of lymphadenectomy can be reduced by ~50% in patients with type I tumors. Critics of this approach have argued that frozen section techniques are unreliable in centers without pathologists familiar with the technique.

## *Surgical Approach*

If reliable frozen section is unavailable or high-risk criteria are identified on frozen section, lymphadenectomy can be performed. To begin the pelvic lymphadenectomy incisions in the broad ligament peritoneum are extended above the pelvic brim toward the white line of Toldt. The pararectal space is developed by bluntly dissecting between the hypogastric vessels and ureter. The paravesical space is developed lateral to the superior vesical arteries to expose the nodal basins along the pelvic sidewalls. Lymph nodes from the hypogastric, external iliac, obturator, and common iliac basins should be removed using a combination of sharp dissection, electrocautery, and/or advanced energy devices. This includes tissues anterior and

medial to the common iliac artery, anterior and medial to the external iliac artery, medial to the external iliac vein, and anterior to the hypogastric artery, extending distally along the superior vesicle artery. The external iliac vein can be retracted laterally with a vein retractor to provide access to hypogastric and obturator nodes. The obturator space should be developed with blunt dissection to reveal the course of the obturator nerve, often using the suction tip. The lymph nodes anterior to the obturator nerve are removed carefully to avoid disrupting any accessory obturator veins that can arise from the dorsal surface of the external iliac vein **(FIG. 27.4).**

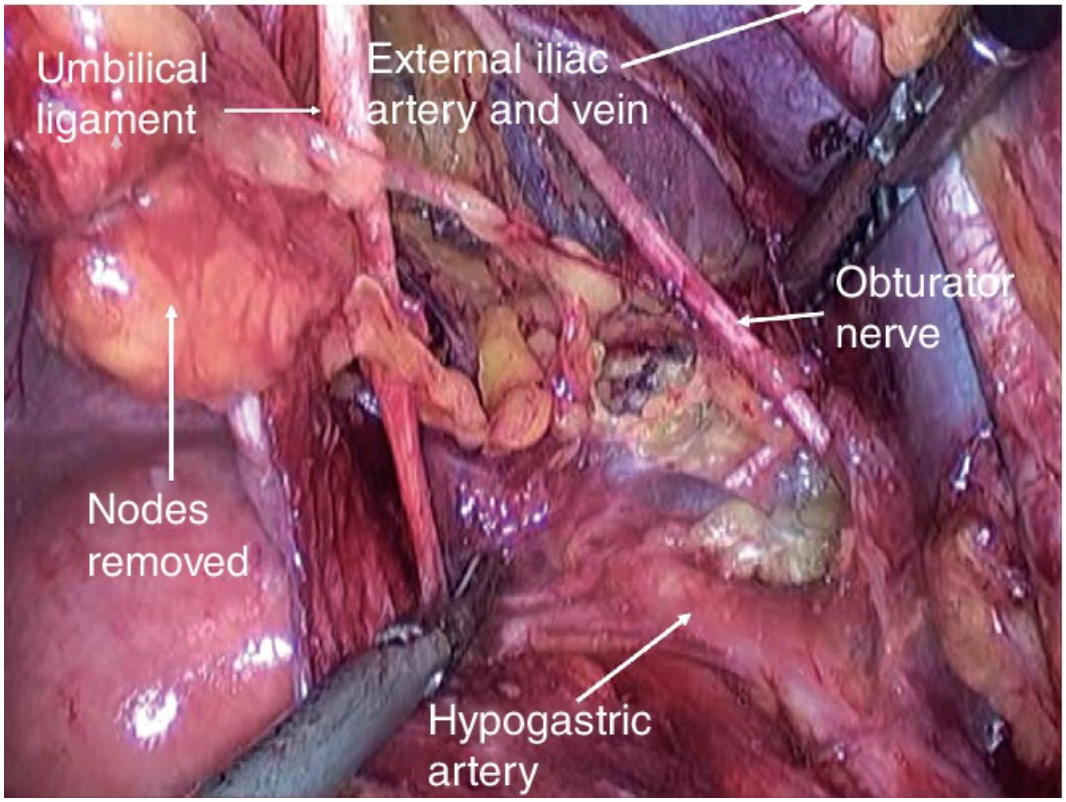



**FIGURE 27.4** Right pelvic lymphadenectomy. (Reprinted with permission from Berek JS, Hacker NF. *Berek and Hacker's Gynecologic Oncology*. 6th ed. Wolters Kluwer; 2015. Figure 21.13.)

The superior margin of the pelvic lymphadenectomy is the mid–common iliac artery. The inferior margin of the dissection is the point at which the circumflex iliac vein crosses over the external iliac artery. The lateral margin of the resection is the psoas muscle. The medial margin of the resection is the ureter, which should be retracted medially during the hypogastric node resection to avoid injury. Damage to the obturator nerve (sensory/motor) and genitofemoral nerve (sensory) can occur even without complete transaction, and these nerves should be dissected carefully away from adjacent nodal bundles to reduce the likelihood of long-term injury.

The left paraaortic lymph node dissection begins at the level of the left mid–common iliac artery, continuing superiorly along the lateral aspect of the aorta. The peritoneal incision along the white line of Toldt can be extended to the level of the renal vessels to expose the nodal basin. Care must be taken to avoid dissecting too far laterally and dorsally to avoid injury to the lumbar arteries arising from the aorta. On the right, the paraaortic lymph node dissection is performed along the anterior surface of the inferior vena cava. The mesentery of the terminal ileum can be retracted anteriorly and to the right. The right ureter should be identified and retracted with the mesentery to avoid injury during lateral dissection of the lymph nodes off the vena cava. The surgeon should be aware of numerous small, perforating vessels on both sides that can bleed, so meticulous dissection is important. Perforator bleeding can be controlled with pressure and use of surgical clips.

The superior border of the paraaortic lymph node dissection remains unsettled. The incidence of isolated paraaortic lymph node metastases in the absence of pelvic lymph node metastases is ~1%-3%. For this reason and taking into consideration the technical challenges of performing higher lymphadenectomy in obese patients, the superior margin of an adequate paraaortic lymph node dissection is often considered to be the level where the inferior mesenteric artery (IMA) arises from the aorta. Single-institution studies have suggested higher than anticipated rates of paraaortic lymph node metastases above the IMA, but this has not been confirmed in other studies. Isolated nodal recurrences above the IMA are rare. As such,

paraaortic lymphadenectomy dissection to the level of the renal vessels can be considered when feasible but should be weighed against the added operative time and risks to complete the dissection.

## Minimally Invasive Hysterectomy

Minimally invasive surgery should be the preferred approach for patients with endometrial cancer. A large, randomized trial comparing open laparotomy and laparoscopic staging for patients with apparent organ-confined endometrial cancer demonstrated noninferior recurrence-free survival with the laparoscopic approach. More recently, gynecologic oncologists have embraced robotic-assisted laparoscopy for endometrial cancer staging. Potential benefits over conventional laparoscopy include greater dexterity, three-dimensional vision, tremor elimination, motion scaling, and improved ergonomics.

Surgeons must carefully select patients for minimally invasive hysterectomy as there is no role for uncontained tissue morcellation for patients with endometrial cancer. To avoid the added morbidity, time, and expense of converting to a laparotomy once it is apparent that the specimen cannot be removed intact through the vagina, an accurate preoperative assessment of uterine size is critical. For obese patients in whom uterine size cannot be determined on pelvic examination, transvaginal ultrasound can provide useful information about vaginal clearance. Due to variability in pelvic anatomy and surgeon expertise, there is no definitive cutoff regarding the upper limit of uterine size amenable to minimally invasive surgery.

If a surgeon determines that a uterine specimen cannot be removed vaginally once the hysterectomy is completed, the uterus can be placed in a durable specimen bag and left in situ while the vaginal cuff is closed. A minilaparotomy can then be performed to remove the specimen without necessitating specimen morcellation. Patients who undergo minilaparotomy for specimen removal have a similar course for their postoperative recovery as patients in whom the procedure can be completed without minilaparotomy.

Morcellation should be avoided as loss of bag integrity can result in tumor spill during specimen extraction.

Whether a surgeon chooses a laparoscopic or robotic approach, the overall technique for staging is similar for both minimally invasive approaches. Prior to incision, surgeons must carefully consider trocar placement. With the DaVinci Xi robotic platform (Intuitive Surgical, Inc.), the camera trocar can be placed 15 cm above the pubic symphysis (usually the umbilicus). In cases where standard trocar placement is inadequate to complete the paraaortic lymphadenectomy, the surgical cart can be rotated 180° and the robot redocked with the camera directed toward the head rather than the pelvis. This will facilitate paraaortic lymphadenectomy and/or omentectomy. In obese patients, trocar placement should be based on direct measurement from the pubic symphysis or border of the ribs as landmarks rather than estimation based on location of the umbilicus due to abdominal wall drift caused by the presence of a pannus.

# *Surgical Approach*

Prior to abdominal entry, surgeons should consider whether to place a uterine manipulator. A randomized trial demonstrated equivalent survival with a laparoscopic vs open approach. However, results of a phase III randomized trial comparing minimally invasive vs open hysterectomy for cervical cancer demonstrated inferior survival with the minimally invasive approach. One potential mechanism for this outcome was an increased risk of peritoneal dissemination caused by use of a uterine manipulator. As the previously mentioned endometrial cancer trial did not assess the use of uterine manipulators as a confounder for survival during laparoscopic hysterectomy, we do not have high quality data assessing this question. At this time, studies regarding the impact of uterine manipulator use on survival outcomes of women undergoing minimally invasive hysterectomy are shown mixed results. Therefore, many surgeons continue to use uterine manipulators during their procedures.

After laparoscopic entry, an abdominal survey is performed in a similar fashion as to that performed during laparotomy. Although tissues cannot be palpated, the view is magnified, which may lead to identification of subtle abnormalities that cannot be appreciated during laparotomy. After examining the upper abdomen, patients are placed in Trendelenburg position and the bowel swept out of the pelvis. For patients undergoing robotic-assisted surgery, Trendelenburg positioning must be adequate for lymphadenectomy from the start of the case to avoid redocking the robot for this procedure. This usually requires more Trendelenburg than would be required to complete hysterectomy alone. A variety of atraumatic laparoscopic retraction devices can be used to improve visibility and prevent bowel injury. In cases where the sigmoid is obscuring the view, an epiploica can be sutured to the abdominal wall to retract the colon out of the pelvis. This can also be performed by applying a laparoscopic tie to an epiploica and bringing it through the anterior abdominal wall in the upper abdomen using a Carter-Thomason needle. Tension on the suture can be adjusted by shortening or lengthening where the suture is clamped at the abdominal wall.

The pelvic sidewalls are opened in a similar fashion as the open approach with the exception that the round ligament should not be divided until after the pararectal space is developed. This will maintain countertraction of the broad ligament toward the anterior abdominal wall during dissection, leading to a more open operative field. The remainder of the hysterectomy can be performed as one would do for benign indications. Once the colpotomy has been performed, the surgeon must be careful to avoid spilling tumor contents into the abdominal cavity during transvaginal specimen extraction. Suturing the colpotomy ring to the cervix can prevent the specimen from falling away from the colpotomy site. Different approaches to robotic hysterectomy for endometrial cancer are demonstrated in **VIDEOS 27.1** and **27.2**.; **VIDEO 27.2** includes sentinel node mapping.

# Minimally Invasive Lymphadenectomy

Pelvic lymphadenectomy can be performed in a similar fashion as the open approach discussed earlier. Careful attention to surgical planes and perforating vessels will allow the surgeon to maintain better hemostasis. Energy devices such as the argon beam coagulator can aid dissection and hemostasis during minimally invasive pelvic lymphadenectomy.

The right paraaortic lymph nodes are accessed by incising the peritoneum over the right common iliac artery with care to avoid injury to the ureter running laterally. The incision is extended cranially along the aorta. Under ideal circumstances, this incision can be extended to the level of the duodenum. A tent is then created under the mesentery of the terminal ileum to expose the vena cava. The right ureter should be identified but not dissected away from the mesentery, so that it will remain out of the operative field during further dissection. Once the vena cava is exposed, the overlying lymph nodes are carefully resected. Lymphatic tissue should be dissected away from the border of the common iliac artery and aorta before the lateral and superior margins are dissected to avoid uncontrolled bleeding. An average of three perforating veins will anastomose between the vena cava and overlying nodal tissue during this dissection. Larger vessels should be ligated with bipolar energy or surgical clips before being divided. If bleeding is encountered during this step, inserting a laparotomy sponge, and applying pressure for 1-2 minutes will preclude the need for suturing.

As the lateral boundary of the descending colon is difficult to access with conventional port placements, the approach to minimally invasive left paraaortic lymphadenectomy is substantially different compared to the open approach. Having already creating a peritoneal incision along the aorta to perform the right-sided dissection, a tent is created in the mesentery of the sigmoid colon at the pelvic brim. Lymph nodes will be immediately visible on the left lateral edge of the aorta, and it is important to definitively identify the ureter prior to beginning the dissection so that cautery can be used safely if bleeding occurs. As with the right side, the ureter should be dissected away from the overlying mesentery so that it is retracted out of the field. The dissection should be performed from a distal/medial to proximal/lateral direction with care to ligate any

perforating vessels as they are encountered. The superior boundary of the low paraaortic lymph nodes is the origin of the IMA. Further dissection above the IMA can be performed by incising the peritoneum along the aorta above the IMA. If a suprapubic port is utilized, the left paraaortic dissection can also be extended above the IMA by directing the camera located at the suprapubic port in a cranial direction and working under the sigmoid mesentery lateral to the IMA. This step can be technically challenging depending on the location of the origin of the IMA, as this will substantially impact the mobility of the sigmoid mesentery. Bleeding in this area can usually be stopped with placement of a laparotomy sponge, pressure, and/or application of a topical hemostatic agent **(BOX 27.1).**

## BOX 27.1 STEPS IN THE PROCEDURE

### Minimally Invasive Surgery for Endometrial Cancer

- Dorsal lithotomy position, prep and drape.
- Select abdominal entry location based on patient habitus and extent of lymphatic assessment.
- Explore abdomen and obtain peritoneal washings.

### Hysterectomy

- Divide round ligaments at pelvic sidewalls.
- Open pararectal and paravesical spaces; identify and remove suspicious lymph nodes.
- Oophorectomy can be omitted in young women with low-risk type I tumors.
- Divide uterine arteries, cardinal ligaments, and uterosacral ligaments at lateral margin of corpus to ensure extrafascial resection.
- Ensure cervix is completely removed during colpotomy.

- Remove specimen vaginally and avoid uncontained morcellation.

### Staging Procedures

- Frozen section of uterus is performed to triage high-risk patients to lymphadenectomy.
- Pelvic lymphadenectomy should include removal of hypogastric, external iliac, and obturator lymph nodes. Or consider SLN.
- Paraaortic lymphadenectomy should extend at least to the level of the origin of the IMA.
- Omentectomy is considered for type II tumors.

## Sentinel Lymph Node Mapping

Lymphadenectomy is performed for many patients with endometrial cancer because the presence of metastatic lymph node guides postoperative therapy and predicts survival. This prognostic information comes at the cost of increased morbidity caused by lymphedema, lymphocyst formation, and other perioperative complications. In a recently published prospective trial evaluating the incidence and morbidity of lymphedema following lymphadenectomy, 22% of women experienced both a 10% increase in lower extremity volume and significant symptoms of lower extremity dysfunction during 2 years of follow-up.

The primary objective of SLN mapping is to obtain information about lymph node status without subjecting patients to the morbidity of full lymphadenectomy. Studies from breast cancer, melanoma, and vulvar cancer demonstrate the accuracy and reduced morbidity of SLN mapping when performed by experienced surgeons. In patients with endometrial cancer, one to two sentinel nodes are expected to be removed from each side of the pelvis. Retrospective studies suggest that lymphedema risk is minimal when SLN mapping is performed for lymphatic assessment of endometrial cancer.

Accurate detection of SLNs is primarily dependent upon surgeon experience. The prospective FIRES trial of SLN mapping followed by completion lymphadenectomy demonstrated a bilateral SLN detection rate of 58% with 86% of patients having at least one SLN identified. The rate of false-negative SLN mapping (SLN negative and non–SLN positive) was <3%, similar to results from breast cancer trials in which SLN mapping is already the standard of care. NCCN guidelines now support SLN mapping as an alternative lymph node assessment strategy.

## *Injection*

The most widely used technique for SLN mapping involves injecting dye into the stroma of the cervix with a 22-gauge spinal needle prior to placement of the uterine manipulator (**FIG. 27.5A** and **B**). In a study by Sinno et al., injection of indocyanine green (ICG) dye demonstrated superior bilateral SLN identification than did isosulfan blue dye. With ICG dye injection, a fluorometric camera is used to identify SLNs in the pelvis. ICG is diluted to a concentration of 1.25 mg/mL and injected at the 3 and 9 o'clock positions of the cervix, 1 mL 8 mm deep, and 1 mL just under the cervical mucosa. Slow injection over several seconds will result in less dye leaking through the injection site and more successful mapping. Injection of more than the recommended amount of dye will not usually improve mapping success. If anything, this will result in overstaining of the retroperitoneum and make identification of lymphatic channels more difficult.

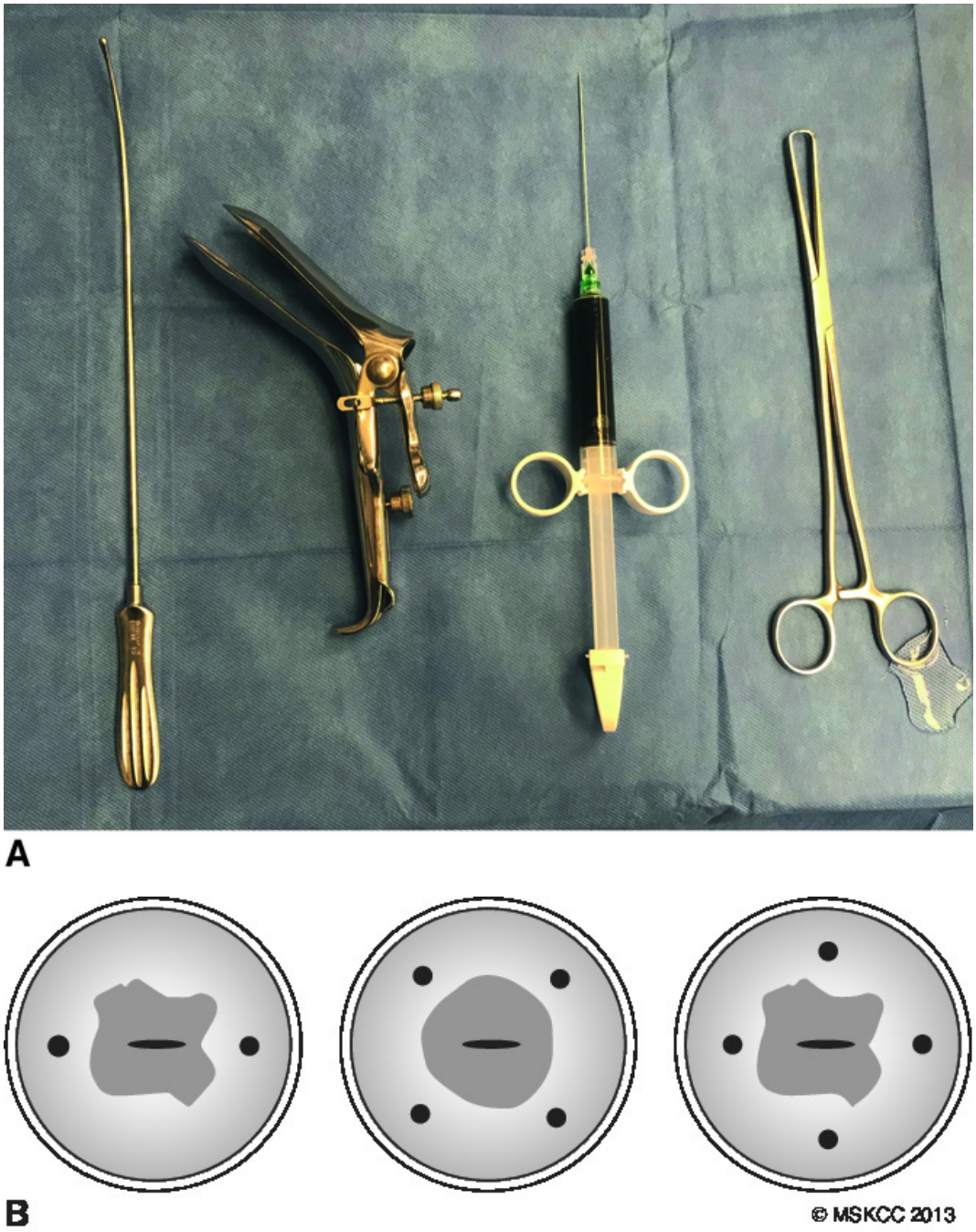



**FIGURE 27.5** **A.** Setup for cervical injection of indocyanin green dye during SLN mapping for endometrial cancer. A 22-gauge spinal needle is used to inject dye at the time of uterine manipulator placement. **B.** Options for cervix

injection sites. Injection at the 3 and 9 o'clock position is most used and most successful (*far left image*). (Copyright © 2022 Memorial Sloan Kettering Cancer Center. All rights reserved.)

Other SLN mapping techniques have also been evaluated. This dye injection method does not require additional imaging technology and is performed during open procedures but results in inferior SLN detection rates in morbidly obese patients. The combination of radiocolloid and blue dye injection has been extensively evaluated but does not clearly improve mapping rates as would be warranted by the added cost and complexity that this approach requires. Carbon nanoparticles have also been evaluated as an alternative SLN mapping technique with similar results as isosulfan blue dye but without the risk of allergic reactions. Fundal and hysteroscopic tumoral injection sites have also been explored. In a meta-analysis by Bodurtha Smith, cervical injection resulted in the highest rate of SLN identification. Higher rates of paraaortic SLN identification are observed with noncervical injection locations, but these findings are of unclear significance given the low risk of isolated paraaortic metastasis in endometrial cancer (1%-3%).

# *Surgical Approach*

SLNs should be identified and excised immediately upon completion of the laparoscopic peritoneal survey. If used, mapping will be more successful if the uterine manipulator is well managed by the bedside assistant. To begin, the uterus is directed toward the contralateral side of the pelvis. The posterior leaf of the broad ligament is opened from the round ligament to the pelvic brim. The round ligament should not be transected at this step, as retaining this connection to the pelvic sidewall will lead to better ventral countertraction of the retroperitoneal space boundaries during subsequent steps. During the entire dissection, careful attention to hemostasis will prevent the

field from being obscured by blood. Insertion of a small laparotomy sponge will allow the surgeon to control bleeding easily without the need for a skilled assistant. As the pararectal space is developed, deeper levels of the retroperitoneum will remain unsullied if bleeding is controlled before venturing deeper. In most cases, lymphatic channels in the parametria can be followed along the uterine vessels until their insertion into the hypogastric vessels (**FIG. 27.6A-C**). From this point, channels may branch in different directions; the hypogastric, obturator, and external iliac nodal basins are the most common locations for SLN identification. In cases where a channel is seen leading directly to a noncolored node, the node should still be sent as an SLN if the lymphatic pathway to the node is obvious. In many patients, an external iliac lymph node will be illuminated immediately upon opening the retroperitoneum. The surgeon must confirm that a more proximal node is not present underneath the external iliac vein, as is the case in most patients.

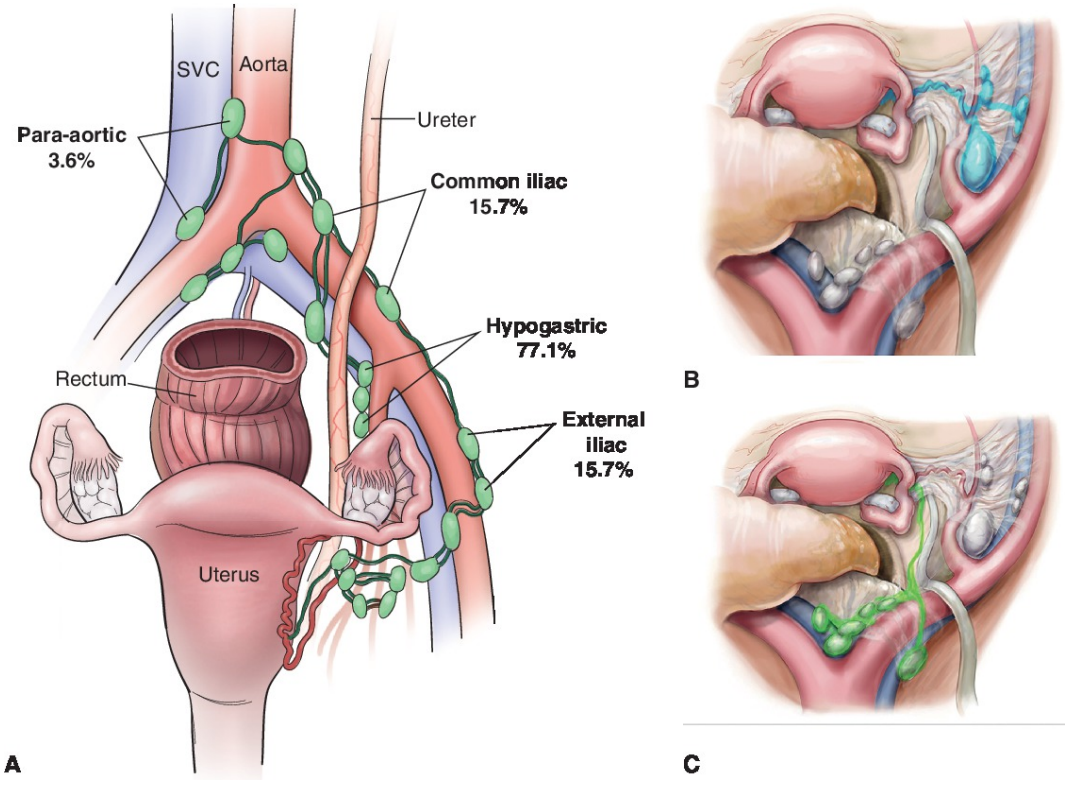
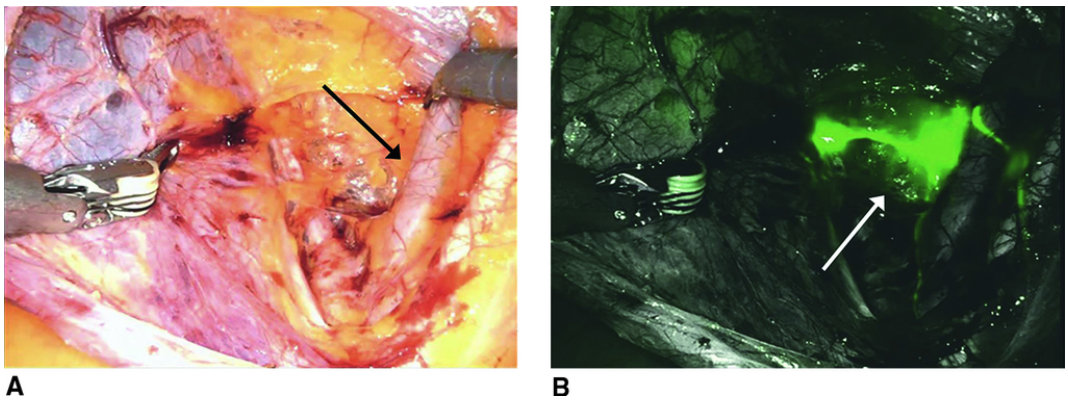


**FIGURE 27.6** **A.** The distribution of SLN mapping locations in patients with endometrial cancer. **B.** Sentinel lymph nodes commonly map to hypogastric region. (Copyright © 2022 Memorial Sloan Kettering Cancer Center. All rights reserved.) **C.** Less commonly mapped area to presacral region. (Copyright © 2022 Memorial Sloan Kettering Cancer Center. All rights reserved.)

In a small percentage of cases, the lymphatics will follow a medial path adjacent to the ureter, usually leading to a proximal external iliac, common iliac, or paraaortic SLN. To avoid missing these uncommon SLN locations, it is important to always examine tissue adjacent to the ureter for a medial channel even if an SLN is identified in a more common location. SLNs will be identified in the paraaortic region in 3% of cases with cervical injection, corresponding closely to the risk of isolated paraaortic metastasis. Suspicious lymph nodes should be removed, regardless of whether they are identified as sentinel nodes (**FIG. 27.7** and **VIDEO 27.3**).



A B

**FIGURE 27.7** Images of SLN mapping in the pelvis. **A.** View of right pararectal space.

*Black arrow* points to right external iliac artery. **B.** *White arrow* indicates SLN in hypogastric region after ICG injection and using fluorometric camera for visualization.

In cases where SLN mapping fails, NCCN guidelines currently recommend completion pelvic lymphadenectomy (**FIG. 27.8**). This is based on the concept that lymphatic obstruction due to tumor infiltration is a primary factor for failed SLN mapping. In experienced hands, the NCCN algorithm will result in a low rate of side-specific lymphadenectomy (<20%). Novel strategies employing frozen section to triage type I tumors that have failed to map bilaterally appear to reduce the need for lymphadenectomy, a significant concern as most patients with failed mapping are node negative. In a recent study evaluating the use of frozen section in patients who failed to map to an SLN, application of Mayo criteria decreased the need to perform lymphadenectomy from 18% to 7%. Some surgeons have reported success with re-injection of the cervix in the event of a failed mapped. If attempted, this must be performed before transecting the lymphatic channels in the parametria, as further mapping will not be accurate if the retroperitoneal lymphatic channels have already been disrupted (**BOX 27.2**).

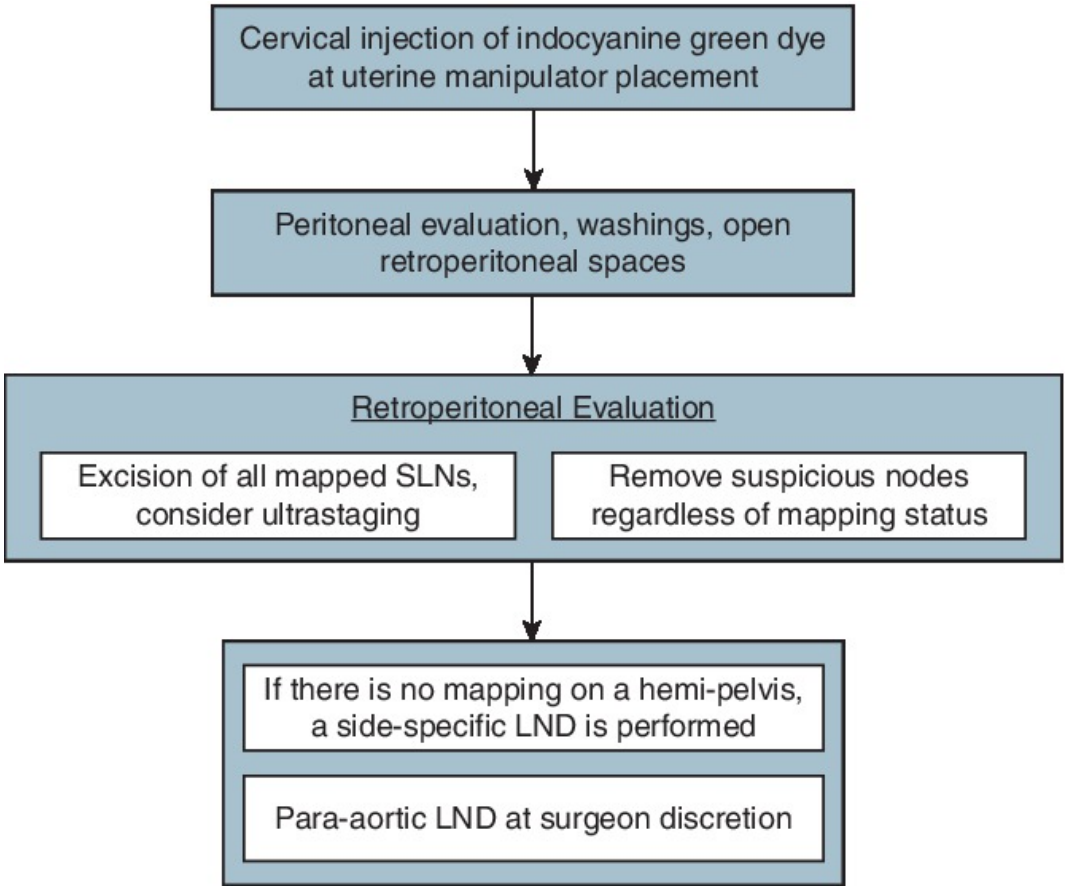



**FIGURE 27.8** An algorithm for lymphatic assessment in endometrial cancer using sentinel lymph node mapping. (Adapted from Barlin JN, Khoury-Collady F, Kim CH, et al. The importance of applying a sentinel lymph node mapping algorithm in endometrial cancer staging: beyond removal of blue nodes. *Gynecol Oncol*. 2012;125(3):531-535. Copyright © 2012 Elsevier. With permission.)

## BOX 27.2 STEPS IN THE PROCEDURE

### Sentinel Lymph Node Mapping

- ICG is be diluted to a concentration of 1.25 mg/mL.
- ICG is injfected using a spinal needle at the 3 and 9 o'clock positions of the cervix, with 1 mL of solution injected deep (8 mm) and 1 mL injected superficially into the submucosa.
- Cervical injection of ICG should occur at the time of uterine manipulator placement.
- Develop pararectal and paravesical spaces.
- Identify and excise SLNs prior to hysterectomy.
- Enlarged nonsentinel lymph nodes should also be removed.

## *Pathologic evaluation of SLN*

Once SLNs have been excised, pathologic ultrastaging can be performed. Ultrastaging differs from standard pathology processing by adding additional levels of sectioning to detect low volume metastatic disease. These sections are stained at additional levels with hematoxylin and eosin and immunohistochemical assays for cytokeratins (AE1:AE3). Kim and colleagues demonstrated a 3.8%-6.9% increased rate of micrometastasis and/or isolated tumor cell identification with ultrastaging. As with breast cancer, it remains unclear whether patients with only isolated tumor cells in SLN should receive adjuvant therapy. Multiple retrospective studies suggest that patients with isolated tumor cells have a similar prognosis as node-negative patients with similar uterine risk factors.

# SPECIAL CLINICAL SCENARIOS

## Surgery for the Morbidly Obese Patient

It would be difficult to identify a malignancy in which obesity has a greater impact on both the pathogenesis and management of a disease than endometrial cancer. Obesity is a significant risk factor for the development of type I endometrial cancer. As BMI increases, the risk of cancer increases. Similarly, the risk of death from endometrial cancer also increases with BMI. In a meta-analysis by Secord et al., the odds ratio of death from endometrial cancer was 1.66 for patients with a BMI ≥ 40 when compared to nonobese patients.

Endometrial cancer is one of many obesity-related illnesses that can reduce life expectancy. There is currently no evidence that weight loss will reduce the risk of endometrial cancer recurrence, even for obesity-related subtypes. Diet and lifestyle modifications have the more quantifiable benefit of improving intercurrent illnesses, such as cardiovascular disease and diabetes. Addressing obesity is of particular importance for younger patients, in whom an endometrial cancer diagnosis often occurs several years prior to the development of other obesity-related conditions. For younger patients desiring fertility preservation, returning to a healthy weight may improve fertility outcomes and reduce pregnancy-related complications. If diet and lifestyle modifications are unsuccessful, obese patients may be referred for bariatric surgery consultation once primary therapy is complete.

Obesity creates a variety of surgical challenges, especially when performing minimally invasive procedures. Steep Trendelenburg positioning of overweight patients is critical to successful completion of paraaortic lymphadenectomy and to access the pelvis in the morbidly obese. A variety of materials are available to secure patients to the bed so that they will not slide once positioned, including bean bags and foam padding. The patient’s chest can be padded and taped to prevent sliding when placed in Trendelenburg. Obese patients should be positioned in anticipation of sliding a few centimeters during the procedure. Adjusting for this movement is especially critical for uterine manipulation, as the range of motion of the manipulator may be impaired by a patient sliding up the bed.

Successful minimally invasive surgery in obese patients requires support from an anesthesiologist with experience managing obese

patients. The combination of steep Trendelenburg positioning and abdominal insufflation can result in a dramatic reduction in functional residual capacity. Increasing extrinsic positive end expiratory pressure and reducing tidal volume can mitigate depressive effects of anesthesia. Surgeons should be familiar with the ventilator management strategies to successfully complete minimally invasive surgery in obese patients. In many cases, surgery can be completed at a lower insufflation pressure (12 mm Hg), even in obese patients. This can increase the likelihood that a patient will tolerate insufflation long enough to successfully complete the procedure. Additional anesthetic considerations are discussed in Chapter 3.

Abdominal entry techniques must also be thoughtfully considered. The umbilicus often drifts lower along the abdominal wall in obese patients due to the dependent nature of the pannus. When lymphadenectomy is indicated, low positioning of the midline trocar can hinder access to structures outside the pelvis. A left upper quadrant entry at Palmer's point using a bladeless optical trocar will allow both for safe entry and appropriate positioning of the midline trocar after insufflation.

Paraaortic lymphadenectomy can be especially challenging in obese patients. In addition to the approaches outlined above, puppeteering sutures can be used to lift the peritoneal edges of the dissection so that the surgeon and assistant can retract bowel loops that drop into the field. Patients who do not tolerate continuous Trendelenburg positioning can periodically be returned to a flat position and the abdomen temporarily desufflated to allow the patients' respiratory status to recover. Ultimately, the decision to continue paraaortic dissection must be weighed against medical comorbidities and the likelihood that the results will impact treatment planning.

# Management of Advanced Disease

Patients with metastatic endometrial cancer present a unique challenge. Resection of all visible disease presents the best opportunity for long-term survival but must be balanced against the risk of morbidity.

Patients with grossly visible cervical extension (stage II) can be treated with surgery and/or radiation. Patients with noninvasive cervical gland involvement can extra-fascial hysterectomy; a cervical biopsy or pelvic MRI should be performed to confirm stromal invasion. Patients with operable stage II tumors may be offered radical hysterectomy with staging in a similar fashion to cervical cancer. Patients who are likely to be offered pelvic radiation regardless of whether a radical hysterectomy is performed may be better served with an extrafascial hysterectomy to avoid the morbidity of combining both modalities of treatment. Patients who are poor surgical candidates can be offered preoperative radiation, followed by extrafascial hysterectomy and lymphadenectomy. This approach potentially avoids some of the morbidity of radical hysterectomy but should not be offered to patients with type II tumors, in whom recurrence rates are unacceptably high with this approach. Patients with inoperable tumors can be offered radiation and/or systemic chemotherapy. If the tumor responds, surgical resection can then be considered.

The decision to perform cytoreduction and/or hysterectomy in patients with distant metastasis to the liver or lungs should be individualized. Patients with unresectable disease need timely administration of systemic therapy to control distant metastases. While some studies suggest that patients with distant metastasis fare better if they undergo hysterectomy at diagnosis, proceeding with surgery first may delay initiation of systemic treatment, especially if complications arise. Many patients with type I tumors can achieve control of bleeding with the addition of oral progestins during chemotherapy. Alternatively, pelvic radiation can also control disease but may impact bone marrow reserve and impact the ability to administer chemotherapy later. A hysterectomy can be considered after the patient has demonstrated a response to chemotherapy as this will control vaginal bleeding in most cases.

# Surgery for Young Patients

Ovarian preservation may be a safe and reasonable option for premenopausal women with early-stage low-grade endometrial

cancer. The risk of occult ovarian metastasis is <5% in women with type I tumors. For patients in whom ovarian preservation is considered and who have normal appearing ovaries, biopsy is not required. While there is some increased risk of ovarian cancer in patients with a history of endometrial cancer, it is felt that this risk will be offset by the benefit of retaining ovarian estrogen production, which reduces cardiovascular disease–related deaths in women. Patients undergoing ovarian preservation should be counseled about the need to return for oophorectomy if occult metastatic disease is identified on final pathology or if Lynch syndrome is diagnosed on subsequent genetic testing.

## SURGERY FOR TYPE II ENDOMETRIAL CANCERS

A few modifications should be made for the surgical management of patients with type II tumors. Most importantly, the overall risk of metastasis is higher for type II tumors. Computed tomography will identify many patients with macroscopic metastases. Surgeons should perform a careful inspection of the abdominal cavity to evaluate for grossly visible disease that was missed or developed after imaging was performed. Occult metastases to the omentum and/or lymph nodes occur in 10%-50% of patients with type II tumors; therefore, full staging, including omentectomy and lymphatic assessment, is recommended for all type II tumors. Studies have shown that SLN mapping is an equally accurate approach for lymph node assessment for patients with high-grade tumors and type II cancers. Patients with advanced-stage disease benefit from tumor debulking, although prognosis remains poor even with complete gross resection.

## SURGERY FOR UTERINE SARCOMAS

Uterine sarcomas account for <5% of all uterine neoplasms. The majority of these are leiomyosarcomas, but other high-grade sarcomas (undifferentiated uterine sarcoma and high-grade

endometrial stromal sarcoma) are also encountered. High-grade sarcomas behave aggressively, with high rates of distant metastasis and recurrence even if confined to the uterus at diagnosis. Patients with low-grade sarcomas (adenosarcoma and low-grade endometrial stromal sarcoma) have a better prognosis, with lower risk of distant metastasis and recurrence.

Unfortunately, most sarcomas are diagnosed postoperatively as there are currently no well-established criteria to diagnose uterine sarcomas prior to hysterectomy. If a sarcoma is identified incidentally, the patient should be referred expeditiously to an oncologist to discuss the risks and benefits of postoperative therapy. If a sarcoma is suspected or identified preoperatively, hysterectomy and complete resection of abdominal disease is recommended. Patients should undergo chest imaging to diagnose potential distant metastasis prior to surgery. Lymph node metastasis is rare with uterine sarcomas and lymphadenectomy is omitted unless obvious nodal involvement is identified. For patients with evidence of distant unresectable metastatic disease at diagnosis, the decision to operate or offer initial chemotherapy should be made in conjunction with an oncologist.

# LYNCH SYNDROME

Patients with Lynch syndrome have a 40%-60% lifetime incidence of endometrial cancer. A family history of colon, endometrial, ovarian, small bowel, or ureteral cancer should prompt referral for genetic screening. Lynch syndrome is an autosomal dominant inherited disorder caused by inactivation of one or more genes responsible for DNA mismatch repair (MMR) and results in microsatellite instability (MSI). For patients with a personal history of endometrial cancer, universal screening for Lynch syndrome is now recommended regardless of family history or age at diagnosis due to increased risk of secondary malignancies in carriers. These include colon cancer (~50%), bladder cancer (~10%), upper urinary tract cancers (~10%), and ovarian cancer (~8%). As a first line of testing, the hysterectomy specimen should be evaluated for loss of DNA MMR protein expression (MLH1, MSH2, MSH6, and PMS2). Tumors with loss of

MLH1 should undergo MLH1 promoter methylation testing as alterations in the promoter region can lead to somatic loss of MLH1 expression without a germ-line abnormality. Between 10% and 35% of tumors will have loss of DNA MMR protein expression, but most of these patients will not have Lynch syndrome. If loss of expression is identified, genetic counseling and germ-line mutation testing is recommended. While the risk of Lynch syndrome is low in postmenopausal women diagnosed with endometrial cancer and no family history, identifying the small number of patients meeting these criteria who are at high risk for colon and other cancer and who would benefit from increased surveillance is worth the added cost of screening. Germline testing for Lynch syndrome could be considered for all women under age 50 with endometrioid endometrial cancer regardless of MMR status (**TABLES 27.6 and 27.7**).

## TABLE 27.6
## Lynch Syndrome–Associated Malignancies

| ORGAN SYSTEM | MALIGNANCY |
|---|---|
| Gastrointestinal | Colon<br>Stomach<br>Hepatobiliary<br>Pancreas<br>Small bowel |
| Gynecologic | Endometrium<br>Ovary |
| Urinary | Kidney<br>Ureter<br>Bladder |
| Other | Central nervous system<br>Sebaceous |

## TABLE 27.7
## Lifetime Risk for Gynecologic Cancers in Patients With Lynch Syndrome

| MISMATCH REPAIR GENE | ENDOMETRIAL CANCER | OVARIAN CANCER |
|---|---|---|
| *MLH1* | 20%-54% | 4%-20% |
| *MSH2* | 21%-49% | 7.5%-24% |
| *MSH6* | 16%-71% | 0%-13.5% |
| *PMS2* | 15% | Small risk |

Data from Lancaster JM, Powell CB, Chen LM, et al. Society of Gynecologic Oncology statement on risk assessment for inherited gynecologic cancer predispositions. *Gynecol Oncol*. 2015;136(1):3-7.

Screening for gynecologic malignancies in Lynch syndrome carriers should be performed as part of a comprehensive cancer risk reduction program. According to American College of Obstetrics and Gynecology guidelines, patients with Lynch syndrome are recommended to undergo annual endometrial biopsies and pelvic ultrasounds starting at age 30-35 despite a paucity of evidence suggesting that this approach reduces cancer-related mortality. Onset of irregular menses should prompt gynecologic evaluation even in the setting of annual endometrial biopsies. At the age of 40-45 or upon completion of childbearing, women should consider undergoing prophylactic hysterectomy and bilateral salpingo-oophorectomy. As occult malignancies can be identified at the time of risk-reducing hysterectomy, preoperative endometrial biopsy is recommended to ensure definitive treatment is completed during a single procedure.

# UNDIAGNOSED ENDOMETRIAL CANCERS

Although preoperative workup will identify most patients with endometrial cancer prior to hysterectomy, a diagnosis of cancer is occasionally made incidentally after surgery performed for other gynecologic indications. In these cases, patients should be managed according to risk factors such as histology, depth of myometrial invasion, presence of lymphovascular space invasion, and/or suspicious lymph nodes on radiologic imaging. Options include observation, a return to the operating room for full staging, or pelvic radiation. Patient medical comorbidities and patient preference should also be considered when making this decision in conjunction with a gynecologic oncologist.

Patients who have undergone uncontained morcellation of an unrecognized carcinoma or sarcoma should undergo CT imaging of the chest, abdomen, and pelvis to assess for evidence of metastatic disease and guide surgical planning. Patients who have undergone morcellation should be assessed for small-volume metastatic disease by diagnostic laparoscopy. Completion oophorectomy, omentectomy, and lymphadenectomy may also be required to adequately stage the patient. Due to poor survival outcomes, postoperative chemotherapy may be indicated for patients who have undergone uncontained morcellation of high-grade uterine sarcomas even if there is no residual disease at the time of second-look surgery.

## KEY POINTS

- Minimally invasive (either laparoscopic or robotic assisted) surgery should be the preferred approach to endometrial cancer surgery whenever safe and feasible.
- Surgical staging for endometrial cancer includes inspection of peritoneal surfaces, extrafascial hysterectomy. Bilateral

salpingo-oophorectomy and lymph node assessment should be individualized based on patient and tumor circumstances. Peritoneal washings are performed at the discretion of the surgeon given their unknown prognostic value.

- Premenopausal women with low-risk (type I) endometrial cancer can safely consider ovarian preservation.
- Sentinel lymph node mapping has emerged as an accurate lymph node assessment strategy and an alternative to performing full lymphadenectomy.
- Sentinel lymph node mapping can be performed by cervical injection of indocyanine green dye results and fluorometric imaging to maximize nodal detection.
- All patients with endometrial cancer should undergo DNA mismatch repair testing of the uterine specimen to rule out Lynch syndrome.
- Uncontained uterine morcellation should not be performed during minimally invasive hysterectomy as survival is negatively impacted if a malignancy is incidentally identified.
- Patients with advanced-stage endometrial cancer who are surgical candidates should undergo tumor debulking with a goal of achieving a complete resection of all abdominal metastatic disease.

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# CHAPTER 28

# SURGERY FOR CERVICAL CANCER

Nadeem R. Abu-Rustum and Vance A. Broach

**Clinical Presentation**

Impact of Nodal Disease on Survival

**Pretreatment Evaluation and Staging**

**Surgical Management of Early Cancer**

Cervical Conization With or Without Lymph Node Assessment

Simple Hysterectomy With Lymph Node Assessment

Fertility-Sparing Radical Abdominal Trachelectomy and Conization

**Radical Hysterectomy**

Positioning

Abdominal Exploration

Development of Paravesical and Pararectal Space

Dissection of Hypogastric Artery, Uterine Artery, Bladder, and Ureter

Dissection of Cardinal Ligament

Vaginal Closure

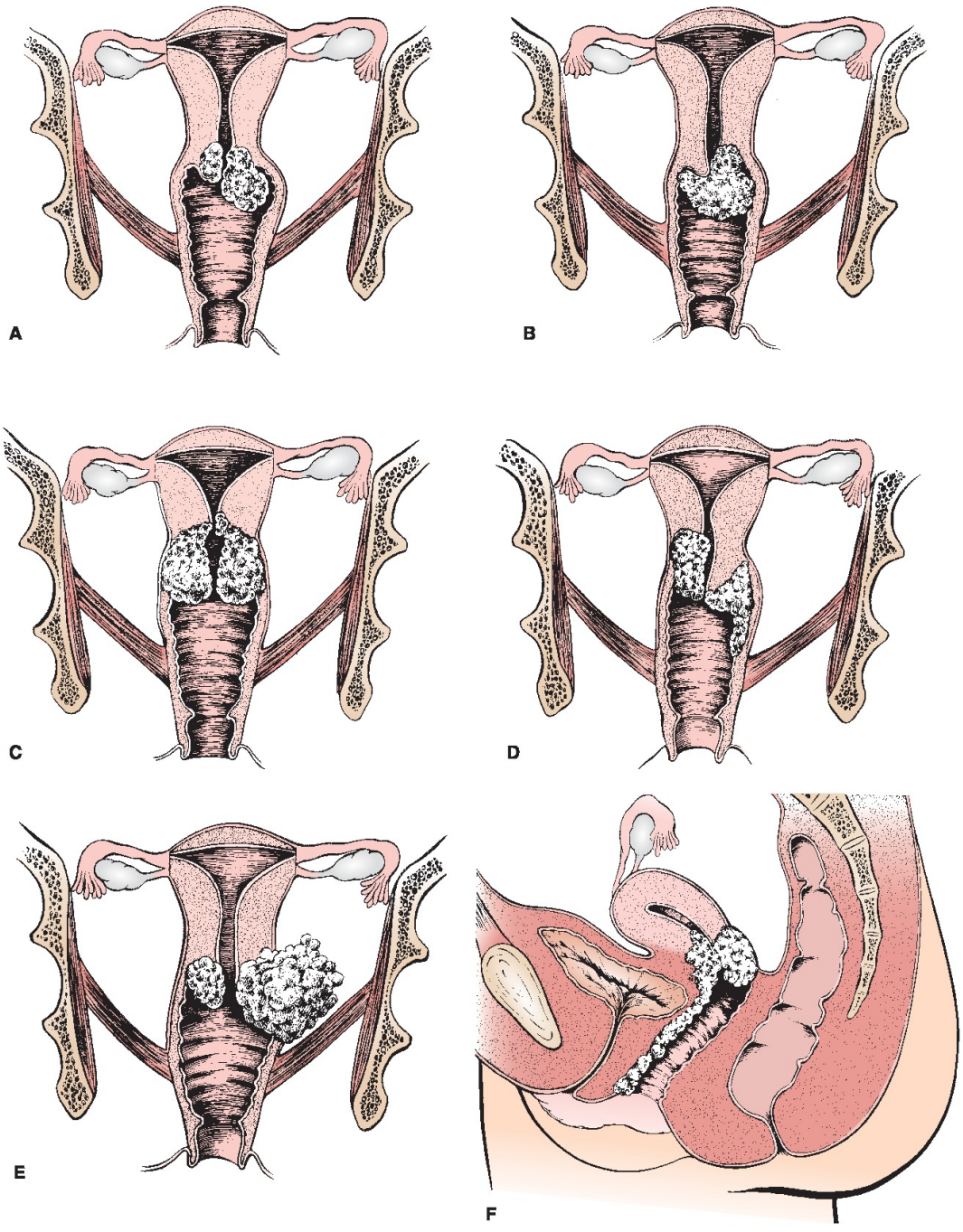
Ovarian Transposition

Lymphadenectomy

**Postoperative Complications**
Urologic Complications
Venous Thrombosis and Pulmonary Embolus
Neuropathy
Rectal Dysfunction
Infection
**Pelvic Exenteration**
Positioning and Preparation
Surgical Approach
**Summary**

In 2021 in the United States 14 000 women will be diagnosed with invasive cervical cancer annually, and 4000 will die of this disease. Worldwide, the burden of this disease is dire, with estimates of 570 000 new cases annually and 300 000 deaths per year. This makes cervical cancer not only the most common gynecologic malignancy but also the third most frequently diagnosed malignancy in women globally after breast and colorectal cancer. In developed countries, and in countries with high human papillomavirus (HPV) vaccination rates, the lifetime risk is ~1%. However, 80% of cases worldwide occur in developing countries, where cervical cancer accounts for 15% of female malignancies. The highest incidence rates are observed in Latin America, the Caribbean, sub-Saharan Africa, and South and Southeast Asia. This geographical disparity is attributed to the absence of effective screening and treatment programs, as epidemiologic and biologic studies have not shown significant differences in tumor biology in these regions. This is compounded by the low rates of HPV vaccination rates in these areas. In 1937, the Health Organization of the League of Nations adopted a clinical classification system for cervical cancer, making it the first cancer to be classified. Recommendations for clinical classification were adopted by the General Assembly of the International Federation of

Gynecology and Obstetrics (FIGO) in 1961, and descriptions of the clinical stages were most recently updated by FIGO in 2018 (**FIG. 28.1**; **TABLE 28.1**).



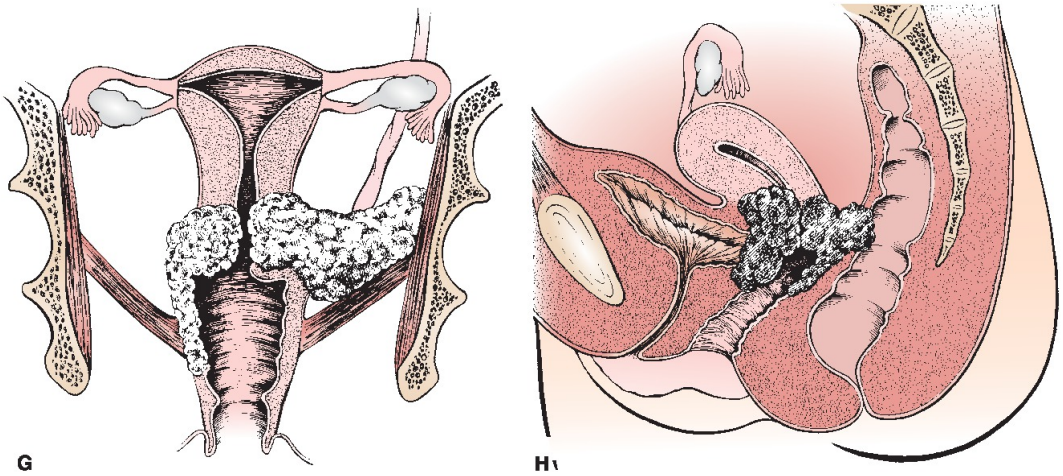



**FIGURE 28.1** FIGO classification of carcinoma of the cervix. **A.** Stage IB: carcinoma confined to the cervix, exophytic. **B.** Stage IB: carcinoma is confined to the cervix, "cauliflower" lesion. **C.** Bulky stage IIA lesion with involvement of the vaginal fornix. **D.** Stage IIA: carcinoma extends into the upper vagina or fornix. **E.** Stage IIB: carcinoma extends into the parametrium but does not extend to the pelvic wall. **F.** Stage IIIA: carcinoma involves the anterior vaginal wall, extending to the lower third. **G.** Stage IIIB: the parametrium is infiltrated, and the carcinoma extends to the pelvic wall. **H.** Stage IVA: the bladder base or rectum is involved.

## TABLE 28.1
## FIGO 2018 Staging of Carcinoma of the Cervix Uteri with 2019 corrigendum

Stage I:
The carcinoma is strictly confined to the cervix (extension to the corpus should be disregarded)
- **IA** Invasive carcinoma that can be diagnosed only by microscopy with maximum depth of invasion ≤5 mm[a]
  - **IA1** Measured stromal invasion ≤3 mm in depth
  - **IA2** Measured stromal invasion >3 mm and ≤5 mm in depth
- **IB** Invasive carcinoma with measured deepest invasion >5 mm (greater than stage IA); lesion limited to the cervix uteri with size measured by maximum tumor diameter[b]
  - **IB1** Invasive carcinoma >5 mm depth of stromal invasion and ≤2 cm in greatest dimension
  - **IB2** Invasive carcinoma >2 cm and ≤4 cm in greatest dimension
  - **IB3** Invasive carcinoma >4 cm in greatest dimension

Stage II:
The cervical carcinoma invades beyond the uterus but has not extended onto the lower third of the vagina or to the pelvic wall
- **IIA** Involvement limited to the upper two-thirds of the vagina without parametrial invasion
  - **IIA1** Invasive carcinoma ≤4 cm in greatest dimension
  - **IIA2** Invasive carcinoma >4 cm in greatest dimension
- **IIB** With parametrial invasion but not up to the pelvic wall

Stage III:
The carcinoma involves the lower third of the vagina and/or extends to the pelvic wall and/or causes hydronephrosis or nonfunctioning kidney and/or involves pelvic and/or paraaortic lymph nodes
- **IIIA** Carcinoma involves lower third of the vagina, with no extension to the pelvic wall
- **IIIB** Extension to the pelvic wall and/or hydronephrosis or nonfunctioning kidney (unless known to be due to another cause)
- **IIIC** Involvement of pelvic and/or paraaortic lymph nodes **(including micrometastases)**,[c] irrespective of tumor size and extent (with r and p notations)[d]
  - **IIIC1** Pelvic lymph node metastasis only
  - **IIIC2** Paraaortic lymph node metastasis

Stage IV:
The carcinoma has extended beyond the true pelvis or has involved (biopsy proven) the mucosa of the bladder or rectum. A bullous edema, as such, does not permit a case to be allotted to stage IV
- **IVA** Spread of the growth to adjacent organs
- **IVB** Spread to distant organs

[a]Imaging and pathology can be used, when available, to supplement clinical findings with respect to tumor size and extent, in all stages.
**Pathological findings supercede imaging and clinical findings.**

[b]The involvement of vascular/lymphatic spaces should not change the staging. The lateral extent of the lesion is no longer considered.

[c]Isolated tumor cells do not change the stage, but their presence should be recorded.

[d]Adding notation of r (imaging) and p (pathology), to indicate the findings that are used to allocate the case to stage IIIC. For example, if imaging indicates pelvic lymph node metastasis, the stage allocation would be stage IIIC1r; if confirmed by pathological findings, it would be stage IIIC1p. The type of imaging modality or pathology technique used should always be documented. When in doubt, the lower staging should be assigned.

From Corrigendum to “Revised FIGO staging for carcinoma of the cervix uteri” [*Int J Gynecol Obstet*. 2019;145:129-135] *Int J Gynaecol Obstet*. 2019;147(2):279-280. doi:10.1002/ijgo.12969. Erratum for: *Int J Gynaecol Obstet*. 2019;145(1):129-135. Copyright © 2019 International Federation of Gynecology and Obstetrics. Reprinted by permission of John Wiley & Sons, Inc.

The principal histologic type of invasive cervical cancer is *squamous* carcinoma, accounting for 80% of cases. *Adenocarcinoma* of the

cervix is increasing in incidence, especially in younger women. In a review of the Surveillance, Epidemiology, and End Results (SEER) Cancer Incidence Public-Use database (1973-1996), Smith and colleagues reported that although the age-adjusted incidence rates per 100 000 for all invasive cervical cancers and squamous cell cancers decreased by 37% and 42%, respectively, the rates for adenocarcinoma of the cervix increased by 29% during the study period.

Not infrequently, adenocarcinoma and squamous cell carcinoma coexist in the same tumor, and these lesions are referred to as *adenosquamous carcinomas*. The so-called *glassy cell adenocarcinoma* of the cervix is rare and is a variant of poorly differentiated adenosquamous carcinoma. Both are known to be clinically aggressive and are associated with frequent development of distant metastasis. *Clear cell adenocarcinoma* of the cervix can occur in the presence or absence of intrauterine exposure to diethylstilbestrol (DES). *Neuroendocrine* tumors represent a small subset (2%) of cervical cancers, among which most are small cell malignancies. These are also clinically aggressive tumors and frequently associated with distant metastases. A rare form of squamous cell cancer of the cervix is *verrucous carcinoma*. This is a very well-differentiated squamous cell carcinoma with extensive keratinization. It usually presents as a large bulky cervical tumor and may be confused with large condylomas, such as those seen on the vulva. Verrucous carcinomas are characterized by a sharp line between the tumor and underlying cervical stroma. Like most cervical cancers, this tumor is associated with HPV infection. Unlike most squamous cell and adenocarcinomas of the cervix, gastric type cervical adenocarcinomas are a mucinous adenocarcinoma. These are not associated with HPV infection and have an aggressive and recalcitrant clinical course.

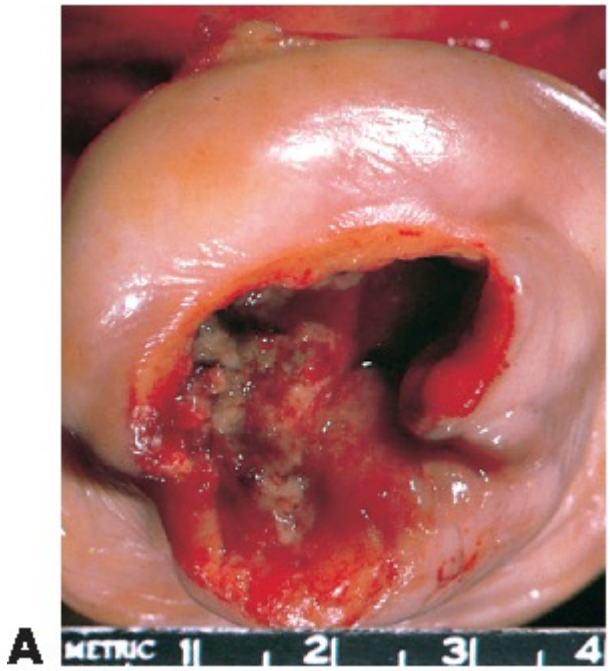
# CLINICAL PRESENTATION

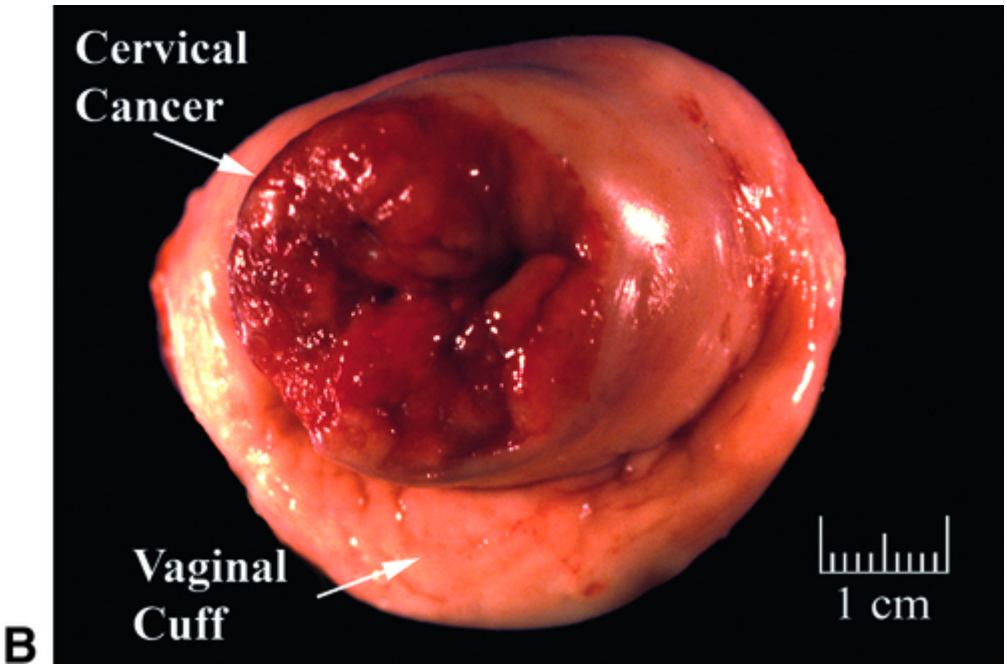
Invasive cervical cancer causes symptoms such as abnormal vaginal bleeding (menorrhagia, metrorrhagia, postcoital bleeding, and postmenopausal bleeding) and discharge. Many patients experience

a profuse and often malodorous discharge, especially when the disease is advanced. Thus, any patient with abnormal vaginal bleeding or discharge should have a pelvic examination, including a speculum examination with visualization of the cervix. Pain is not a common symptom unless the disease is locally advanced and has invaded the adjacent pelvic structures, including pelvic nerves. In more advanced stages, patients may report urinary or bowel symptoms related to tumor involvement of the bladder or rectum. When the disease becomes advanced and involves lumbosacral and sciatic nerve roots and the lateral pelvic sidewall, patients will experience pelvic pain that radiates down their leg. Edema of the lower extremities reflects tumor obstruction of lymphatic and/or venous drainage and is also a sign of advanced disease. Palpable supraclavicular or inguinal adenopathy suggests distant spread. Ascites is uncommon in cervical cancer, as is peritoneal dissemination, and both symptoms portend poor outcome. Approximately one-third of patients with advanced-stage (stage III or IV) disease report having symptoms for <3 months. Invasive cervical lesions can be exophytic, infiltrative, ulcerative, or occult. An everted exophytic carcinomatous growth may be friable. On inspection, the friable exophytic cancer shows a rough, granular, bleeding surface that is sloughing, and infected or necrotic, with foul-smelling discharge.

A tumor that develops beneath the mucosa of the ectocervix and infiltrates the cervical stroma usually causes cervical enlargement (expansion) with or without surface changes. The surface of the cervix may still feel smooth, but the cervical consistency is firm, hard, or nodular on palpation. An ulcerative lesion may look like a large punched-out ulcer but more commonly appears as an irregular crater with a necrotic bleeding base and foul-smelling discharge. The normal contour of the cervix is absent in these ulcerative cases, and there is complete loss of a significant portion of the ectocervix. Any grossly visible lesion of the cervix is considered suspicious for cancer, and biopsy should be performed. Colposcopic examination is unnecessary and not particularly effective for evaluating a gross cervical lesion, but in the setting of a small surface lesion, it may

help to identify the most abnormal area for directed biopsies (**FIG. 28.2A-C**).



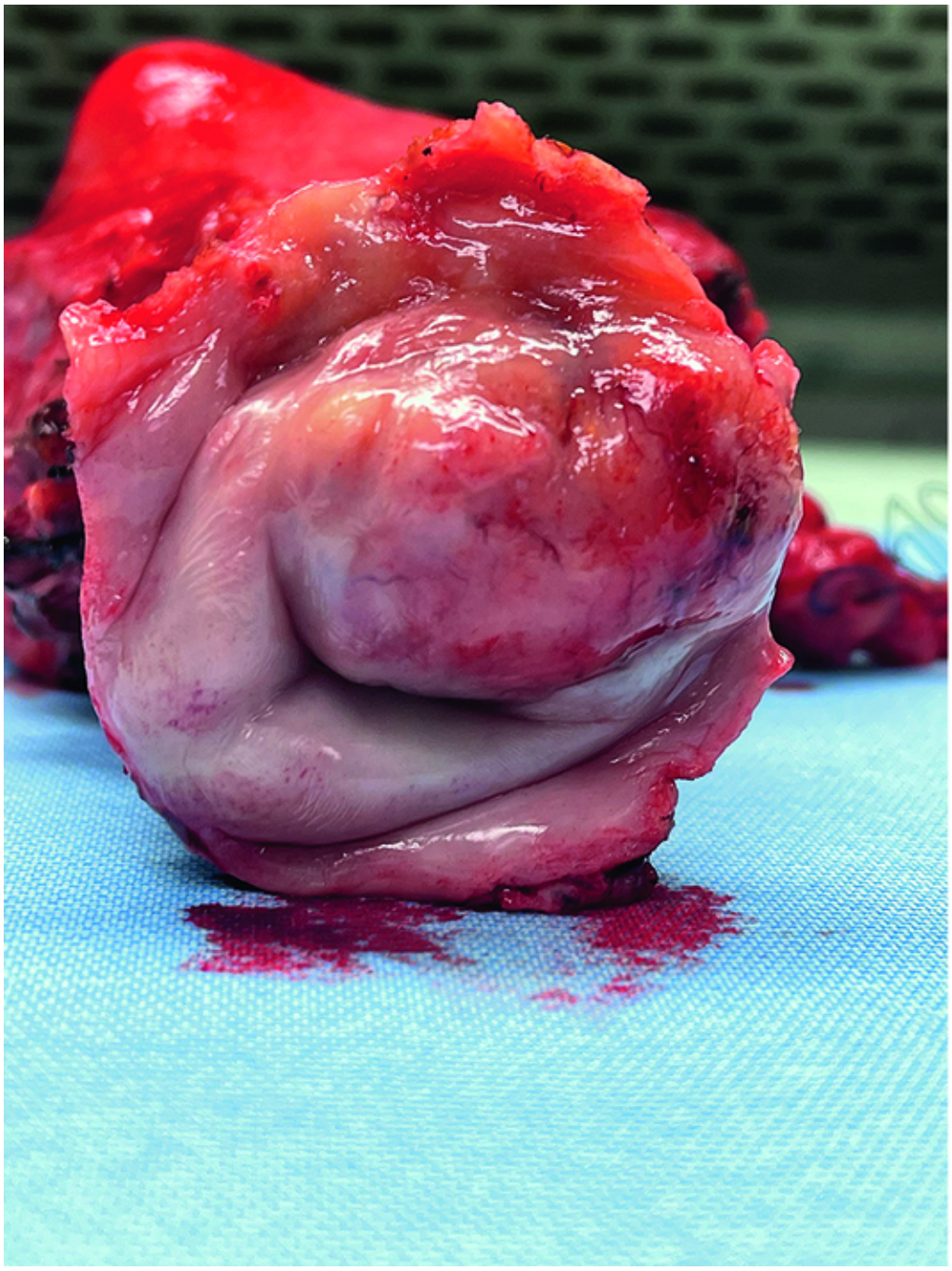



**FIGURE 28.2** Cervix carcinoma. **A.** Ulcerative squamous cell lesion. (Reprinted with permission from Strayer DS, Rubin E. *Rubin's Pathology.* 7th ed. Wolters Kluwer; 2015. Figure 18.20A.) **B.** Exophytic squamous cell

lesion. (Reprinted with permission from Reichert RA. *Diagnostic Gynecologic and Obstetric Pathology.* 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012. Figure 3.150.) **C.** Cervical adenocarcinoma.

The 5-year overall survival rate among all patients with cervical cancer in the United States, irrespective of stage, is ~65%. The most important determinant of prognosis is the FIGO stage. Other prognostic factors include the presence of lymphovascular space invasion (LVSI) and aggressive histologic subtypes (such as neuroendocrine or gastric types).

## Impact of Nodal Disease on Survival

Detection of metastatic lymph nodes is best made by pathologic evaluation and is more accurately determined if lymphadenectomy or sentinel lymph node (SLN) mapping is used in preoperative staging or treatment. Incorporating advanced radiologic imaging such as positron emission tomography (PET), magnetic resonance imaging (MRI), and computed tomography (CT) in the work up of these cancers has improved the detection of nodal metastasis and is included in the newest staging system. The frequency of pelvic node metastases associated with stage is shown in **TABLE 28.2**.

### TABLE 28.2
### Frequency of Metastatic Pelvic Nodes Associated With Stage

| STAGE | FREQUENCY (%) |
|---|---|
| IA1 | 0-1 |
| IA2 | 7-9 |
| IB | 12-20 |
| IIA | 20-38 |
| IIB | 16-36 |
| IIIA, IIIB, and IV | >35 |

Patients with stage IB cervical cancer are primarily treated with radical hysterectomy and pelvic lymphadenectomy, and the 5-year cure rate is ~90% if there are no lymph node metastases. However, if metastatic disease to lymph nodes is present, the 5-year cure rate drops to 65%-80%. The number of metastatic nodes also influences prognosis. Hoskins reported an 83% survival rate for patients with stage IB and IIA disease who had negative lymph nodes at the time of radical hysterectomy and pelvic lymphadenectomy. The survival rate decreased to 57% in patients with one to two metastatic nodes and 31% in those with more than three metastatic nodes.

Most studies agree that metastasis to paraaortic nodes occurs more frequently when disease in pelvic nodes is also present. Even with extended-field radiation therapy, the 5-year survival rate for patients with metastases to the paraaortic nodes is only ~25%-35%. The frequency of paraaortic node metastases associated with stage is shown in **TABLE 28.3**.

## TABLE 28.3
## Frequency of Metastatic Paraaortic Nodes Associated With Stage

| STAGE | FREQUENCY (%) |
|---|---|
| I | 4-7 |
| II | 15-20 |
| IIIA and IIIB | 25-30 |
| IV | 30-50 |

# PRETREATMENT EVALUATION AND STAGING

When a diagnosis of invasive cervical cancer has been established, the clinician should perform an exam to determine whether the tumor is confined to the cervix or extends to the adjacent vagina, parametrium, bladder, ureters, or rectum. To determine the stage, a pelvic exam with palpation, inspection, and estimation of tumor involvement and measurements is preferred. An exam under anesthesia with cystoscopy and proctoscopy will clarify the extent of pelvic disease. Advanced imaging has become standard practice in settings where such imaging is readily available. MRI is the preferred modality to evaluate tumor size and parametrial involvement. CT and PET imaging are useful in evaluating for distant metastases. Twenty percent of patients staged in clinic will be staged differently at exam under anesthesia or with advanced imaging.

Historically FIGO staging included use of diagnostic studies including intravenous urography (IVU), barium enema (BE), and in the case of early-stage disease, a colposcopic study of the vagina and the vaginal fornices. Colposcopic findings may be used to assign tumor stage (eg, FIGO stage IIA), but the results must be confirmed by biopsy. Standard x-rays, such as a chest x-ray and routine bone films, are permissible staging tools (**FIG. 28.3**).

**FIGURE 28.3** Computed tomography scan. *Arrows* point to metastatic retroperitoneal nodes.

In the setting of ureteral obstruction, a tumor is classified as stage IIIB, regardless of the size of the primary lesion. Ureteral obstruction, manifesting as either hydronephrosis or nonfunctioning kidney, is associated with poor prognosis. Retrograde pyelography can be performed for further evaluation, and stenting of the blocked ureter is

recommended. Kidney function studies such as serum creatinine and creatinine clearance should be determined before starting treatment.

In women with bulky or advanced-stage tumors, the bladder mucosa should be inspected cystoscopically for possible bullous edema, which indicates lymphatic obstruction within the bladder wall. Rectal mucosal lesions from cervical cancer are infrequent and should be biopsied at the time of proctosigmoidoscopy because these lesions may represent an inflammatory or neoplastic lesion rather than metastases from the cervix.

Based on pretreatment evaluation including the prognostic factors of tumor size, stage of disease, and risk of pelvic node metastases, a treatment schema is developed for invasive cervical cancer as shown in **TABLE 28.4**. Almost all patients are treated with either primary surgery or primary radiation therapy with concurrent chemotherapy. Some are treated with a combination of all three modalities.

## TABLE 28.4
## Suggested Treatment Schema for Invasive Cervical Carcinoma[a]

| DISEASE STAGE | TREATMENT |
|---|---|
| Stage IA1 | Simple hysterectomy, abdominal or vaginal, or cervical conization |
| | If there is LVI, consider sentinel node mapping or pelvic lymphadenectomy and type B radical hysterectomy |
| Stage IA2 | Type B[b] radical hysterectomy with sentinel lymph node mapping or pelvic lymphadenectomy.[c] Cervical conization with sentinel lymph node mapping or pelvic lymphadenectomy may be acceptable in select patients with 1A2 and IB1disease |
| Stage IB1, IB2, select IB3, IIA | Type C1[b] radical hysterectomy or trachelectomy,[d] bilateral pelvic lymphadenectomy or sentinel node mapping. Consider postoperative radiation, ±concurrent chemotherapy in selected intermediate- or high-risk patients |
| Stage IB3 and bulky IIA | Definitive chemotherapy and radiation or radical abdominal hysterectomy and pelvic (±periaortic) lymphadenectomy[e] |
| Stage IIB-IVA | Definitive chemotherapy and radiation[f] |
| Stage IVB | Chemotherapy |

[a]For individual patients, recommendations for treatment can vary, depending on the clinical circumstances.

[b]See Table 28.7 for Querleu-Morrow classification of radical hysterectomy.

[c]Type B, modified radical hysterectomy, bilateral pelvic lymph node assessment for stage IA2 disease can be considered in select cases.

[d]In highly selected cases where fertility is desired.

[e]Some authorities recommend simple hysterectomy in addition to radiation/chemotherapy for stage IB2 and bulky stage IIA disease.

[f]A patient with a stage IVA lesion that extends only in the anterior or posterior direction may be a candidate for pelvic exenteration.

# SURGICAL MANAGEMENT OF EARLY CANCER

The standard management of early cervical carcinoma includes surgical removal of the cervix and pelvic node evaluation. The extent of resection of the surrounding tissue depends on stage, size of the lesion, and depth of cervical stromal invasion. The patient's desire for fertility preservation should also be determined.

## Cervical Conization With or Without Lymph Node Assessment

The most modest curative procedure is cervical conization. In an exhaustive review of the literature, Ostor identified 31 studies spanning the years 1976-1993 reporting on 3598 patients with squamous cell carcinoma of the cervix with ≤3 mm stromal invasion. Although not all patients had lymph nodes removed as part of their treatment, the calculated incidence of lymph node metastasis in this group was <1%. In 1996, the National Institutes of Health (NIH) invited an international panel of experts to develop a consensus conference statement on cervical cancer. Based on the available studies, this panel concluded that patients with microinvasive squamous cell carcinoma of the cervix with ≤3-mm stromal invasion and negative conization margins have virtually a 100% cure rate when treated with simple hysterectomy or conization alone (**FIG. 28.4**). Microinvasive carcinoma cannot be diagnosed based on a punch biopsy because adjacent areas may contain more advanced

tumor; conization is required for definitive diagnosis in this situation and, in many cases, conization is curative. However, for patients treated by conization alone, both the internal conization margin and the postconization endocervical curettage must be negative because the risk of residual invasive cancer is significantly increased if either the margin or the curettage is positive.

**FIGURE 28.4** Cervical conization specimen with suture at 12 o'clock for orientation.

## Simple Hysterectomy With Lymph Node Assessment

Simple hysterectomy with lymph node assessment (SLN or lymphadenectomy) is an acceptable treatment option for women with

early-stage, small-volume, stage IA1 and select cases of stage IA2. If simple hysterectomy is chosen as the definitive surgical treatment following a diagnostic conization, it should be done within 48 hours of the conization or delayed until the cervix has healed, 6 weeks later. If the hysterectomy is performed after 48 hours and before the cervix has healed, the risk of postoperative morbidity increases due to inflammatory changes associated with the initial cone biopsy.

## Fertility-Sparing Radical Abdominal Trachelectomy and Conization

The first abdominal trachelectomy was performed by Drs. Novak and Aburel in the 1950s. However, it is the work of Daniel Dargent in the early 1990s that revived interest in this procedure. Several investigators, most notably Laszlo Ungar, began to routinely perform the abdominal procedure in 1997, as opposed to the vaginal approach. The operation also appeared suitable for pediatric patients with cervical cancer in whom a vaginal approach was not feasible.

Partial radical organ resection has been accepted in many solid tumors, including partial gastrectomy, nephrectomy, pneumonectomy, and colectomy. In gynecologic oncology, radical trachelectomy, and pelvic lymph node assessment are procedures that can be offered to well-selected patients with early cervical cancer who wish to conceive in the future. This procedure should be distinguished from the abdominal trachelectomy, which is occasionally used for resection of retained cervical stump malignancy following a previous supracervical hysterectomy when fertility preservation is not an issue.

Pelvic lymphadenectomy should be performed with the radical abdominal trachelectomoy. The limits of nodal dissection are the deep circumflex iliac vein caudally and the proximal common iliac artery cephalad. Any suspicious lymph nodes should be sent for frozen section analysis. In our practice, we abandon a fertility-sparing approach if metastatic lymph nodes are identified. SLN biopsy following a structured algorithm is another reasonable option and is followed with pathologic ultrastaging (obtaining extra

histologic sectioins to detect low volume disease) of these SLNs. The removal of paraaortic nodes is also considered for select lesions stage IB1 cancers or greater. The goal of radical abdominal trachelectomy is to resect the cervix, upper 1-2 cm of the vagina, parametrium, and paracolpos in a manner similar to tissue removed in a nerve-sparing radical abdominal hysterectomy while preserving the uterine fundus, tubes, and ovaries.

Regardless of the approach—whether laparoscopic, robotic, or laparotomy—the procedure begins by developing the paravesical and pararectal spaces and dissecting the bladder caudal to the midvagina. The round ligaments are divided (some surgeons preserve the round ligaments), and an atraumatic clamp, such as a Buxton clamp, is placed on the uterine fundus. Care is taken to preserve the cornua and the utero-ovarian pedicles. The infundibulopelvic ligaments, with ovarian blood supply, are kept intact. Care is also taken not to injure the fallopian tubes or disrupt the utero-ovarian ligament.

The uterine vessels are then ligated and divided at their origin from the hypogastric vessels. The parametria and paracolpos with uterine vessels are mobilized medially with the specimen, and a complete ureterolysis is performed. The posterior cul-de-sac peritoneum is incised, and the uterosacral ligament divided; the parametria and paracolpos are divided. The cervical tumor is isolated either with a Wertheim clamp in the open approach or with a stapled vaginal cuff or a similar maneuver in the case of a minimally invasive approach. The specimen is completely separated from the vagina, while keeping its attachment to the utero-ovarian ligaments. The lower uterine segment is then estimated, and clamps are placed at the level of the internal os. The radical trachelectomy is completed by separating the fundus from the isthmus or upper endocervix at ~5 mm below the level of the internal os, if possible.

The uterine fundus with preserved attachments to the utero-ovarian ligaments is placed in the superior part of the pelvis. The specimen—consisting of radical trachelectomy and parametria, with suture marking the vaginal cuff at 12 o’clock—is sent for frozen section evaluation of the endocervical margin. The uterine fundus is inspected, and curettage of the endometrial cavity is performed, as

well as a shave disc margin of the remaining uterine cervical margin, which is sent for frozen section analysis. This is done to ensure that the margin from the reconstructed uterus to the vagina is disease free. A frozen section analysis can be obtained on the distal vaginal margin as well.

If all frozen sections are benign, and at least a 5-mm clear margin is obtained on the endocervical edge, a permanent cerclage with no. 0 Ethibond or no. 0 Gore-Tex suture (knot tied posteriorly) may be placed prior to reconstruction. It should be noted that some surgeons do not recommend cerclage. The uterus is then reattached to the upper vagina with no. 0 or no. 2-0 absorbable sutures in either an interrupted or running fashion. No drains are placed. Standard antibiotic prophylaxis and routine postoperative care is prescribed.

Survival outcomes following radical trachelectomy are comparable to those of radical hysterectomy for similar-sized lesions. It should also be emphasized that adenocarcinoma histology and the presence of LVSI are not contraindications to a fertility-sparing approach (**FIGS. 28.5-28.8**).

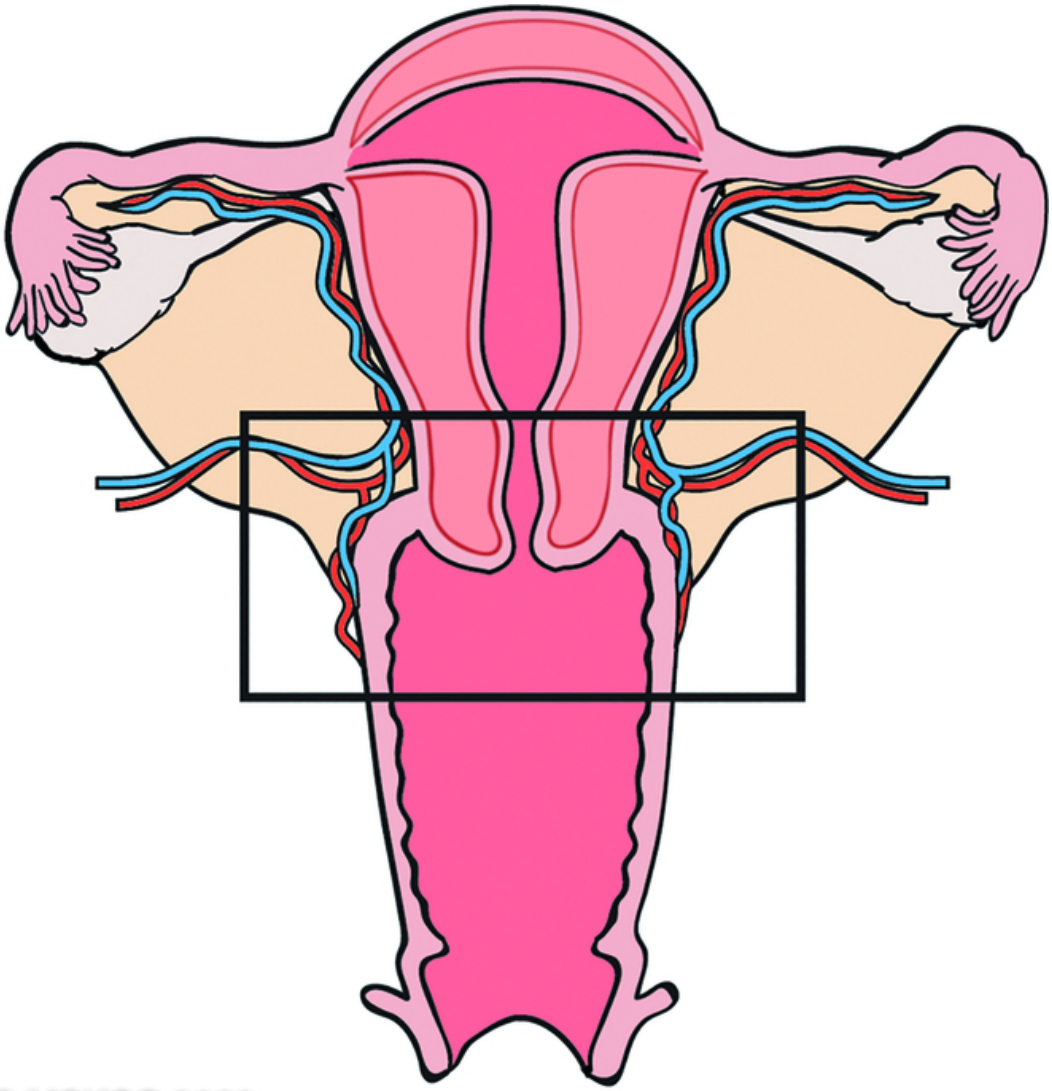



**FIGURE 28.5** Diagrammatic representation of the tissue removed at radical abdominal trachelectomy. (From Abu-Rustum NR, Sonoda Y, Black D, et al. Fertility-sparing radical abdominal trachelectomy for cervical carcinoma: technique and review of the literature. *Gynecol Oncol*. 2006;103(3):807-813. Copyright © MSKCC 2006, Memorial Sloan-Kettering Cancer Center, Memorial

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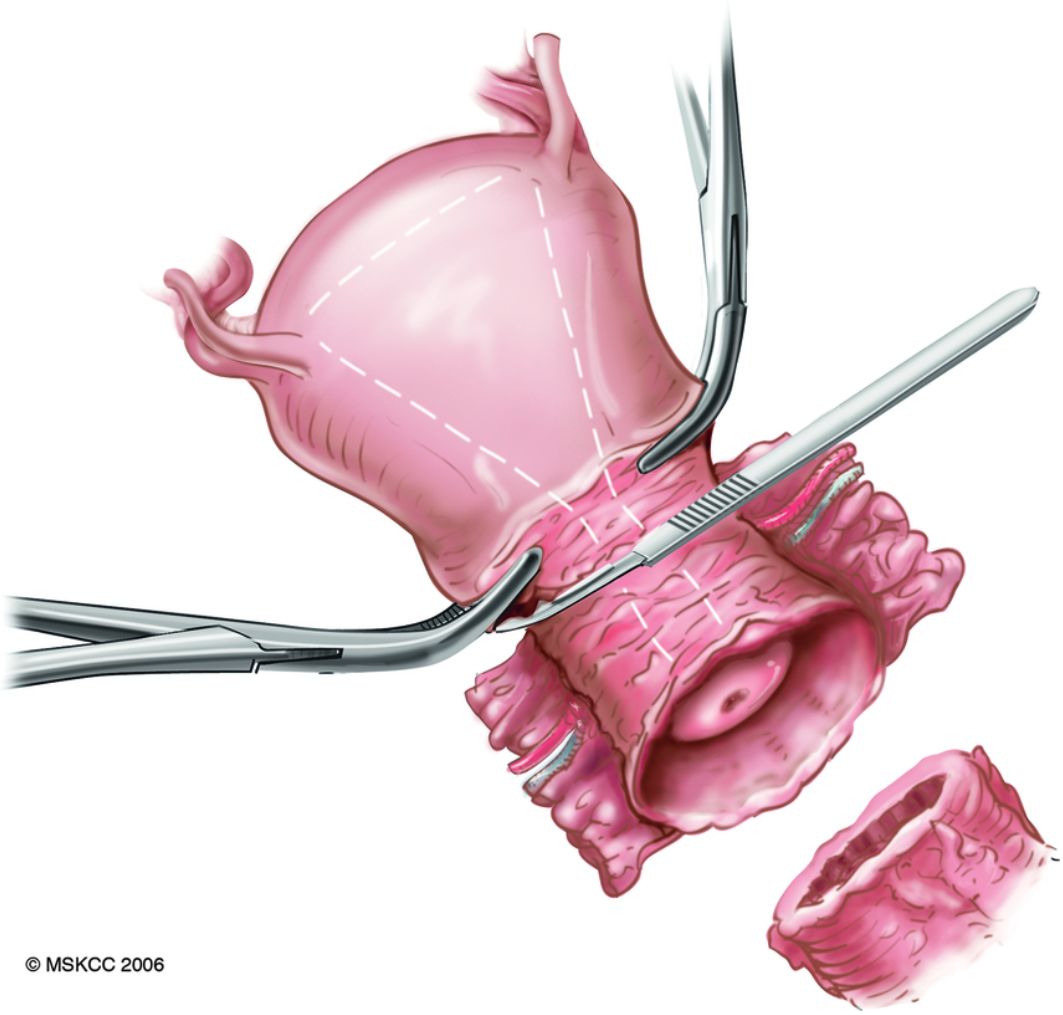



**FIGURE 28.6** The intent of the radical abdominal trachelectomy is to resect the cervix, upper 1-2 cm of the vagina, parametrium, and paracolpos in a similar manner to a type III radical abdominal

hysterectomy but sparing the uterine corpus. (Copyright © MSKCC 2006, Memorial Sloan-Kettering Cancer Center, Memorial Hospital for Cancer and Allied Diseases, and Sloan-Kettering Institute for Cancer Research, each in New York, NY. All rights reserved. Republished with permission.)

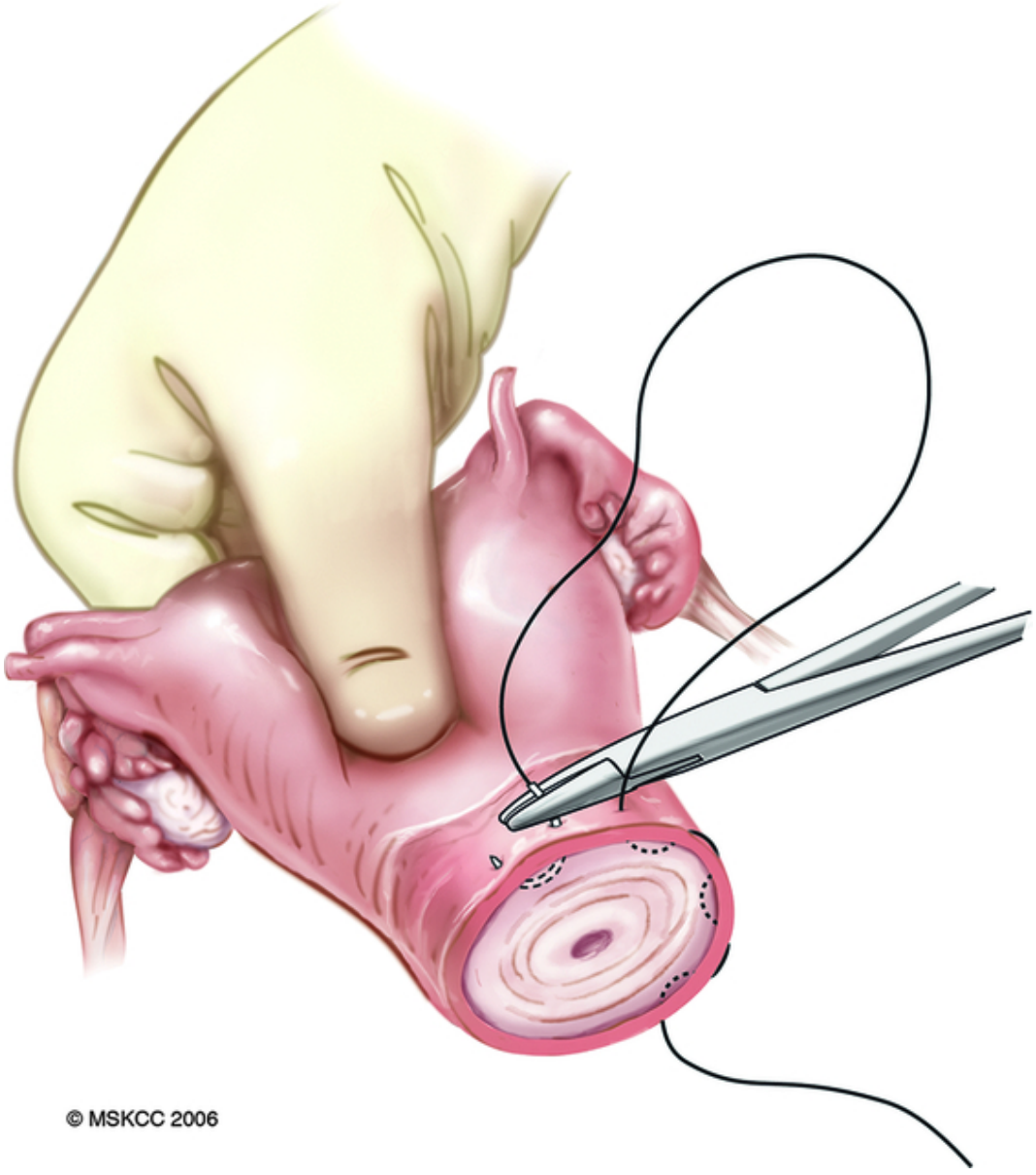


**FIGURE 28.7** A permanent cerclage with no. 0 Ethibond is placed and the knot tied posteriorly. (Copyright © MSKCC 2006, Memorial Sloan-Kettering Cancer Center, Memorial Hospital for Cancer and Allied Diseases, and Sloan-Kettering Institute for Cancer Research, each in New York, NY. All rights reserved. Republished with permission.)

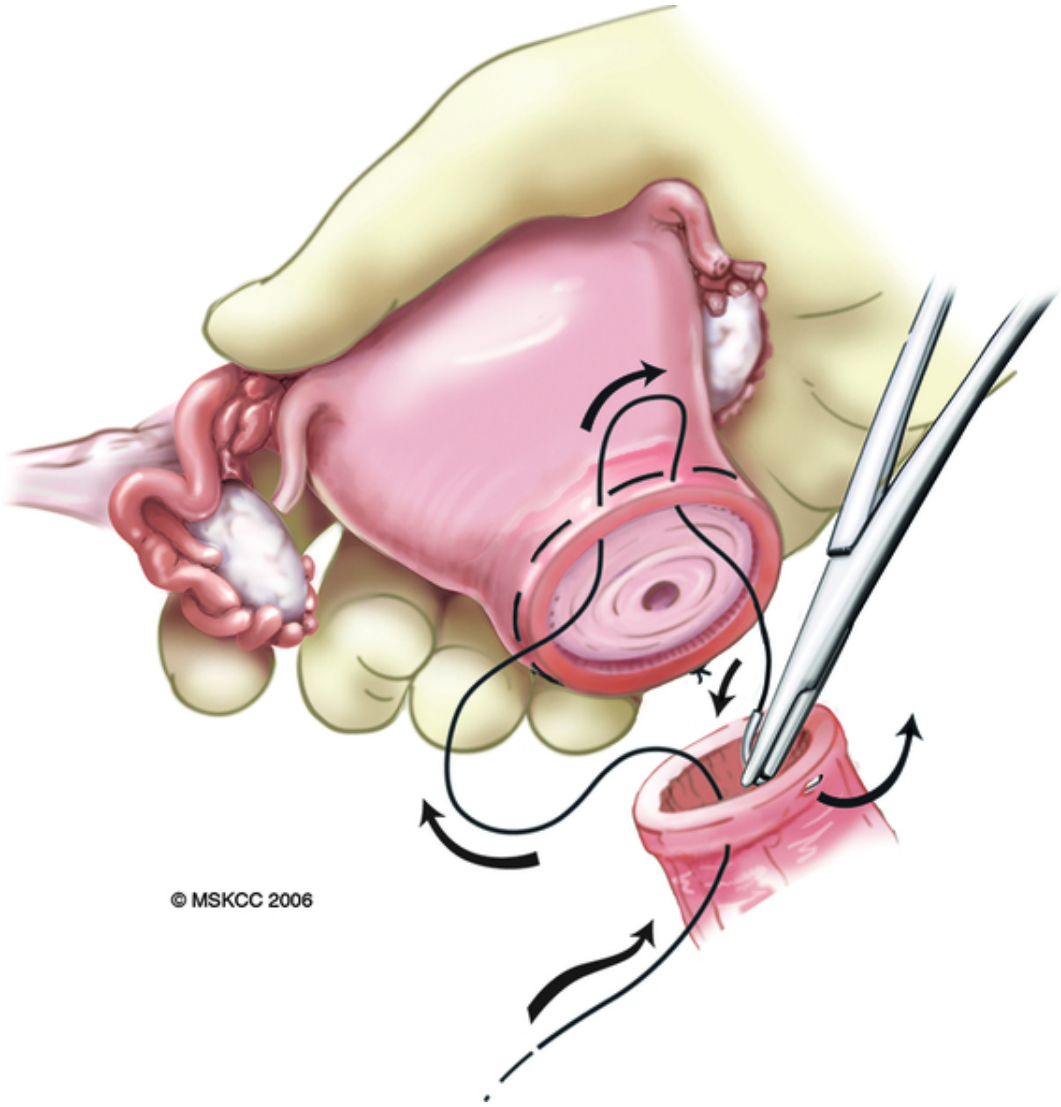


**FIGURE 28.8** Reconstruction of the uterine corpus to upper vagina after the cerclage is placed. (Copyright © MSKCC 2006, Memorial Sloan-Kettering Cancer Center, Memorial Hospital for Cancer and Allied Diseases, and Sloan-Kettering Institute for Cancer Research, each in New York, NY. All rights reserved. Republished with permission.)

The NCCN Cervical Cancer management guidelines now include a full algorithm on surgical treatment options for women with stage IA1-IB2 cervical cancer who wish to preserve fertility, and this includes conization or trachelectomy. Evaluation of pelvic lymph nodes is also necessary in women with stage IA1 disease and LVSI and higher stage cancers. This may be accomplished with SLN mapping or pelvic lymphadenectomy. Pregnancies are possible after both procedures, and overall obstetrical outcome is good, despite the risk of second trimester loss and premature delivery.

## RADICAL HYSTERECTOMY

Radical hysterectomy for cervical cancer was initially performed by Clark in 1895 while he was a resident at the Johns Hopkins Hospital in Baltimore. The procedure is linked in perpetuity to Wertheim of Vienna, who reported a series of 500 cases of radical extended abdominal hysterectomy and partial lymphadenectomy performed from 1898 to 1911. Despite the skill and enthusiasm of Wertheim, Schauta (who developed the radical vaginal hysterectomy in 1901), Okabayashi, and others, radical pelvic surgery was fraught with significant operative morbidity and mortality. In the United States, Meigs reintroduced the radical hysterectomy as the treatment of choice, publishing a series of 344 cases in 1945. Until formalization of training fellowships in gynecologic oncology in the early 1970s,

many outstanding gynecologic surgeons in the United States (Parsons, Ulfelder, Green, and others) made important contributions and modifications to the radical surgical approach that markedly decreased complications while preserving the cure rate.

Although radical hysterectomy and pelvic lymph node assessment are occasionally used to treat patients with adenocarcinoma of the endometrium, we emphasize use of this operation as the primary treatment for invasive cervical cancer. Patients with bulky stage IB disease (FIGO stage IB3) have traditionally been treated with radical hysterectomy and bilateral pelvic lymphadenectomy or primary radiation therapy, with equivalent survival. However, surgically treated patients with these larger lesions have a very high risk of lymph node metastasis, close resection margins, or deep stromal invasion with LVSI, for which adjuvant radiation will be recommended. Therefore, radical hysterectomy is offered for surgical management of most stage IB1, IB2, and select IB3 and IIA cancers. Indications for performing radical hysterectomy are summarized in **TABLE 28.5**. The 1974 Piver-Rutledge-Smith radical hysterectomy classification is shown in **TABLE 28.6**, and the 2008 Querleu-Morrow radical hysterectomy classification is shown in **TABLE 28.7**.

## TABLE 28.5
## Indication for Radical Abdominal Hysterectomy

| INDICATION | EXTENT OF DISEASE |
|---|---|
| Invasive cervical cancer | Stage IA1 with lymphovascular invasion<br>Stage IA2<br>Stage IB1<br>Stage IB2<br>Stage IB3 (selected)<br>Stage IIA1 (selected) |
| Invasive vaginal cancer | Stage I-II (limited to upper one-third of vagina, usually involving posterior vaginal fornix) |
| Endometrial carcinoma | Clinical stage II (gross cervical invasion) |
| Persistent or recurrent cervical cancer after radiotherapy | Clinically limited to cervix or proximal vaginal fornix |

## TABLE 28.6
## Five Classes of Hysterectomy

| | |
|---|---|
| **Class I** | A simple extrafascial total hysterectomy. It is performed for treatment for stage IA1 disease. |
| **Class II** | Also known as a modified radical hysterectomy, removes a more generous vaginal cuff, ligates the uterine artery on the medial side of the ureter (but does not dissect the ureter from the vesicouterine ligament), and removes the inner one-third to one-half of the cardinal ligament. Some surgeons recommend the class II hysterectomy for stage IA2 cervical carcinoma. |
| **Class III** | The classic Meigs procedure, including removal of the entire parametrium and paravaginal tissue as well as the pelvic lymph nodes. |
| **Class IV** | A radical hysterectomy and more extensive procedure where the ureter is completely dissected from the cardinal and vesicouterine ligaments, the superior vesical artery is sacrificed, and three-fourths of the vagina is removed. The uterus and parametria are removed, and a complete lymphadenectomy is performed. |
| **Class V** | A radical hysterectomy and far more extensive procedure, in which the terminal ureter or a segment of the bladder or rectum is removed, along with the uterus, parametria, adnexa, and pelvic lymph nodes. |

## TABLE 28.7
## Surgical Procedures to Treat Early-Stage Cervical Cancer

| TISSUE | CERVICAL CONIZATION | SIMPLE HYSTERECTOMY | MODIFIED RADICAL HYSTERECTOMY TYPE B[a] | RADICAL ABDOMINAL HYSTERECTOMY TYPE C[a] | RADICAL ABDOMINAL HYSTERECTOMY TYPE D1[a] | RADICAL ABDOMINAL HYSTERECTOMY TYPE D2[a] |
|---|---|---|---|---|---|---|
| Cervix uteri | Partially removed | Completely removed | Completely removed | Completely removed | Completely removed | Completely removed |
| Corpus uteri | Preserved | Completely removed | Completely removed | Completely removed | Preserved removed | Completely removed |
| Ovaries | Preserved | May be preserved | May be preserved | May be preserved | May be preserved | May be preserved |
| Parametria and paracolpos | Preserved | Preserved | Removed at level of ureter | Removed lateral to ureter | Removed to the level of the pelvic side wall | Removed with inclusion of fascia and musculature |
| Uterine vessels | Preserved | Ligated at level of cervical internal os | Ligated at level of ureter | Ligated at origin from hypogastric vessels | Hypogastric and obturator vessels removed with uterine vessels | Hypogastric and obturator vessels removed with uterine vessels |
| Uterosacral ligaments | Preserved | Ligated at uterus | Divided midway to rectum | Divided near rectum | Divided near rectum | Divided near rectum |
| Vaginal cuff | Preserved | None removed | 1-2 cm removed | ≥2 cm removed | ≥2 cm removed | ≥2 cm removed |

[a]The 2008 Querleu-Morrow radical hysterectomy (RH) classification is based on the lateral extent of resection and utilizes stable anatomic landmarks to define limits of resection. Four general types of radical hysterectomy are described. Type A (not shown) is a limited RH that includes removal of cervix to the level of the vaginal fornix, including a paracervical margin. Type B RH (modified RH) includes type B1 (ureter is unroofed and mobilized laterally) and type B2 (includes removal of the pelvic lymph nodes). Type C RH includes type C1 (nerve-sparing resection) and type C2 (non-nerve sparing). Type D RH involves ultra-radical resection of structures lateral to the paracervix and includes type D1 (dissection to the pelvic sidewall) and type D2 (resection of the adjacent fascia and musculature).

Traditionally, abdominal radical hysterectomy has been performed via laparotomy with a Pfannenstiel, Cherney, or Maylard incision. However, with the evolution of minimally invasive surgery both laparoscopic and robotic platforms offer new approaches with potential short-term benefits. Numerous retrospective case series demonstrated the feasibility and safety of a minimally invasive approach. Unexpectedly, in 2018, Ramirez reported results of a prospective randomized trial demonstrating that minimally invasive radical hysterectomy was associated with poorer disease-free survival and overall survival than open abdominal radical hysterectomy. Also in 2018, a retrospective analysis of SEER data demonstrated a 4-year mortality rate of 9.1% among women who underwent minimally invasive surgery, compared to 5.3% in those who underwent open surgery. In each of these studies, poorer

outcomes in the minimally invasive group tended to be in women with tumors larger than 2 cm. Since that time, retrospective studies that both refute and support the results of these landmark publications have come forth, and debate regarding the scientific explanation of these findings is ongoing. Multiple additional prospective studies aimed at clarifying these results and better understanding the mechanism of recurrence in the minimally invasive group will help determine what role the minimally invasive approach plays in radical hysterectomy. The surgical principles of identifying tissue planes, mastering anatomy, meticulous dissection, and, very importantly, tumor containment are paramount irrespective of the surgical approach chosen.

# Positioning

After anesthesia is induced, we prefer that the patient be place in the lithotomy position, with the buttocks brought to the edge of the table. Pneumatic compression devices are placed on both lower extremities, and the knees are separated ~90°. The thighs are elevated only 15°-20° relative to the abdomen. In the lithotomy position, the urethral orifice, vaginal introitus, and anal orifice are all available for instrumentation and pressure on the lumbosacral spine is minimized with the legs slightly flexed. After the patient is positioned on the operating table, a careful rectovaginal-abdominal pelvic examination is performed. The skin is prepared from the rib margin to the midthigh, with special attention given to the umbilicus, perineum, and vagina. The patient is draped, a transurethral Foley catheter is inserted into the bladder. If SLN biopsy is planned, injection is performed at the time of examination under anesthesia before the patient is prepped and draped.

# Abdominal Exploration

Before initiating the pelvic procedure, the abdominal viscera and parietal peritoneum are evaluated meticulously for evidence of metastatic disease. The superior and inferior surfaces of the liver are carefully evaluated, as is the region of the celiac plexus. The

undersurface of the diaphragm is particularly vulnerable to metastases, especially the right hemidiaphragm, where the paraaortic lymphatics pass from the abdominal cavity into the mediastinum. The mesentery of the large and small bowel and the serosal surface of the bowel, along with the omentum, should be examined for evidence of metastasis. Suspicious appearing paraaortic nodes should be removed and sent for frozen section. If there is histopathologic evidence of metastatic tumor in a paraaortic lymph node, we do not proceed with a radical hysterectomy and the operation is abandoned. These patients are best treated with concurrent chemotherapy and extended-field radiation therapy.

Peritoneal washings for cytologic examination are not usually obtained because the yield is low, and the prognostic significance is undetermined. At this point in the procedure, any adhesions in the pelvis are lysed, and the intestines are placed in the upper abdomen. An evaluation of the extent of pelvic tumor is undertaken at this time by examining the course of the lymphatic drainage of the pelvis, which is carefully palpated along the pelvic vessels. When enlarged or clinically suspicious nodes are found, they are removed and immediately sent for frozen section, and further evaluation of the pelvis is continued. The paravesical and pararectal spaces are important anatomic landmarks. When developed, they provide an opportunity for thorough exploration of the intervening base of the broad ligament (**FIG. 28.9**). Tumor extension into the base of the broad ligament may not be anatomically evident or detectable prior to the operation. This step is important to further evaluate possible extension of tumor beyond the cervix into the immediate paracervical tissues. If there is evidence of extracervical disease, the surgical procedure may be abandoned unless there is clear evidence that all disease can be removed. The lateral pelvic wall must be free of tumor. If there is evidence of metastatic disease in the pelvic lymph nodes, postoperative pelvic irradiation is indicated. Once it is determined that the central tumor is clearly resectable, radical hysterectomy is initiated.

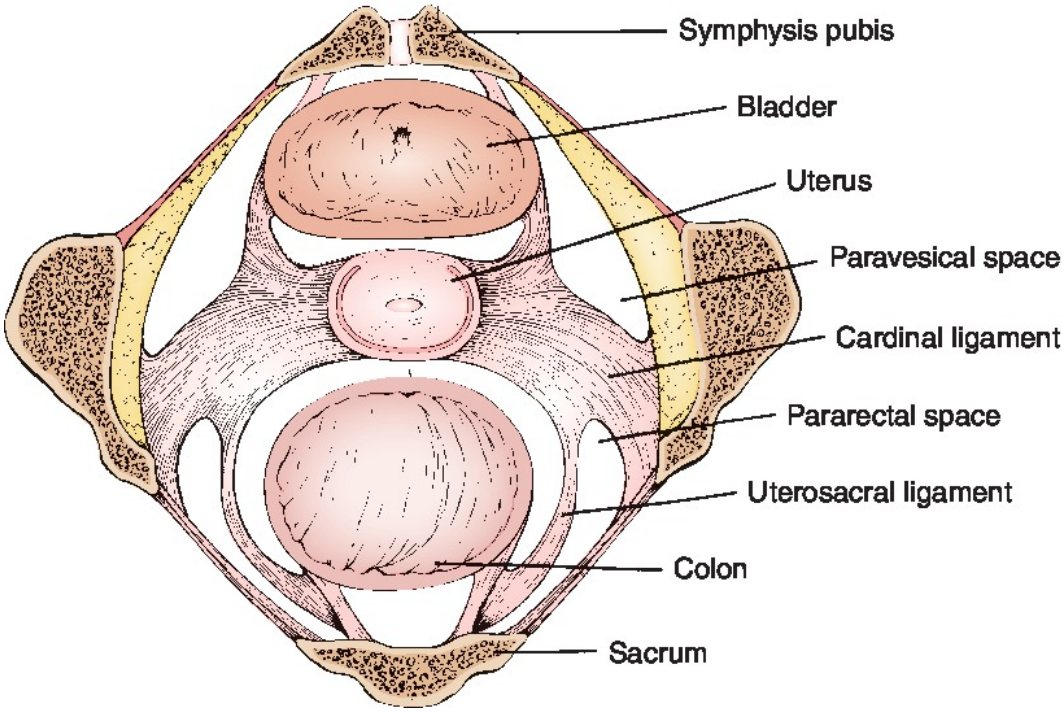
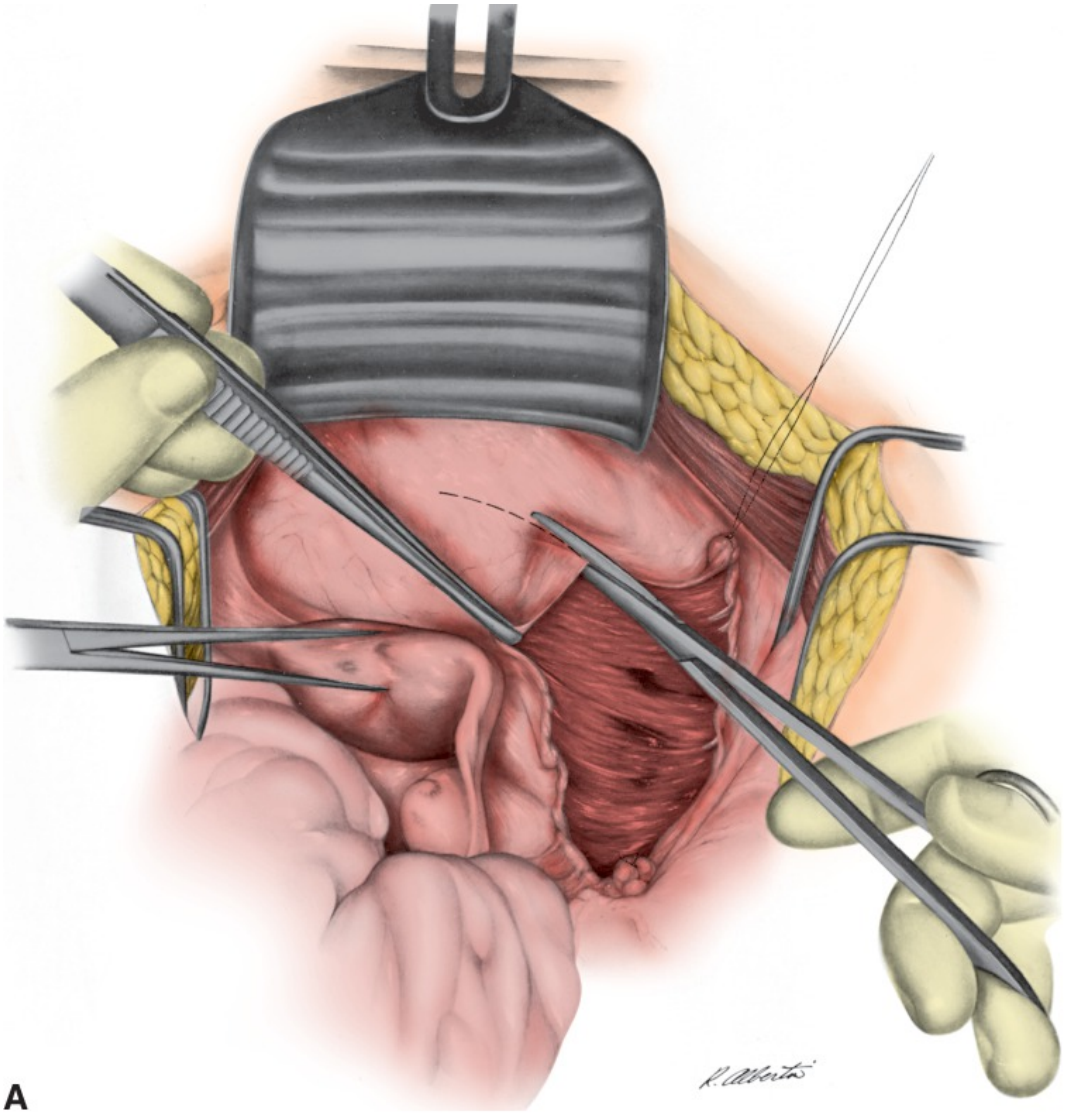



**FIGURE 28.9** Cross section of pelvis showing paravesical and pararectal space. The base of the broad ligament (cardinal ligament) extends to the lateral pelvic wall and contains the major lymphatics draining the cervix.

Before the pelvic planes and spaces are developed, a decision must be made regarding conservation or removal of the ovaries. In premenopausal patients with normal ovaries, the tubes may be removed, and the ovaries retained. In cases of cervical adenocarcinoma, the rate of occult ovarian metastases may be 5%, and the risks and benefits of ovarian preservation should be discussed with the patient preoperatively.

## Development of Paravesical and Pararectal Space

The paravesical space occupies the area between the bladder and the retropubic space medially, with the pelvic sidewall and obturator muscle forming the lateral boundaries. The superior boundary is formed by the cardinal ligament, and the floor comprises the levator ani muscle. After clamping and ligating the round ligament about midway along its course, the anterior leaf of the broad ligament is opened in an inferior direction, passing well into the pelvis before diverting the incision medially to reflect the bladder peritoneum from the lower uterine segment (**FIG. 28.10A**). The dissection is carried down to the levator ani muscle (**FIG. 28.10B**). There are no major blood vessels in this potential space, although, occasionally, an aberrant obturator vessel emerges from the inferior epigastric artery and courses along the posterior aspect of the pubic bone to the obturator space. With gentle dissection, the pelvic floor can be palpated, and the posterior aspect of the space identified, including the anterior margin of the cardinal ligament.



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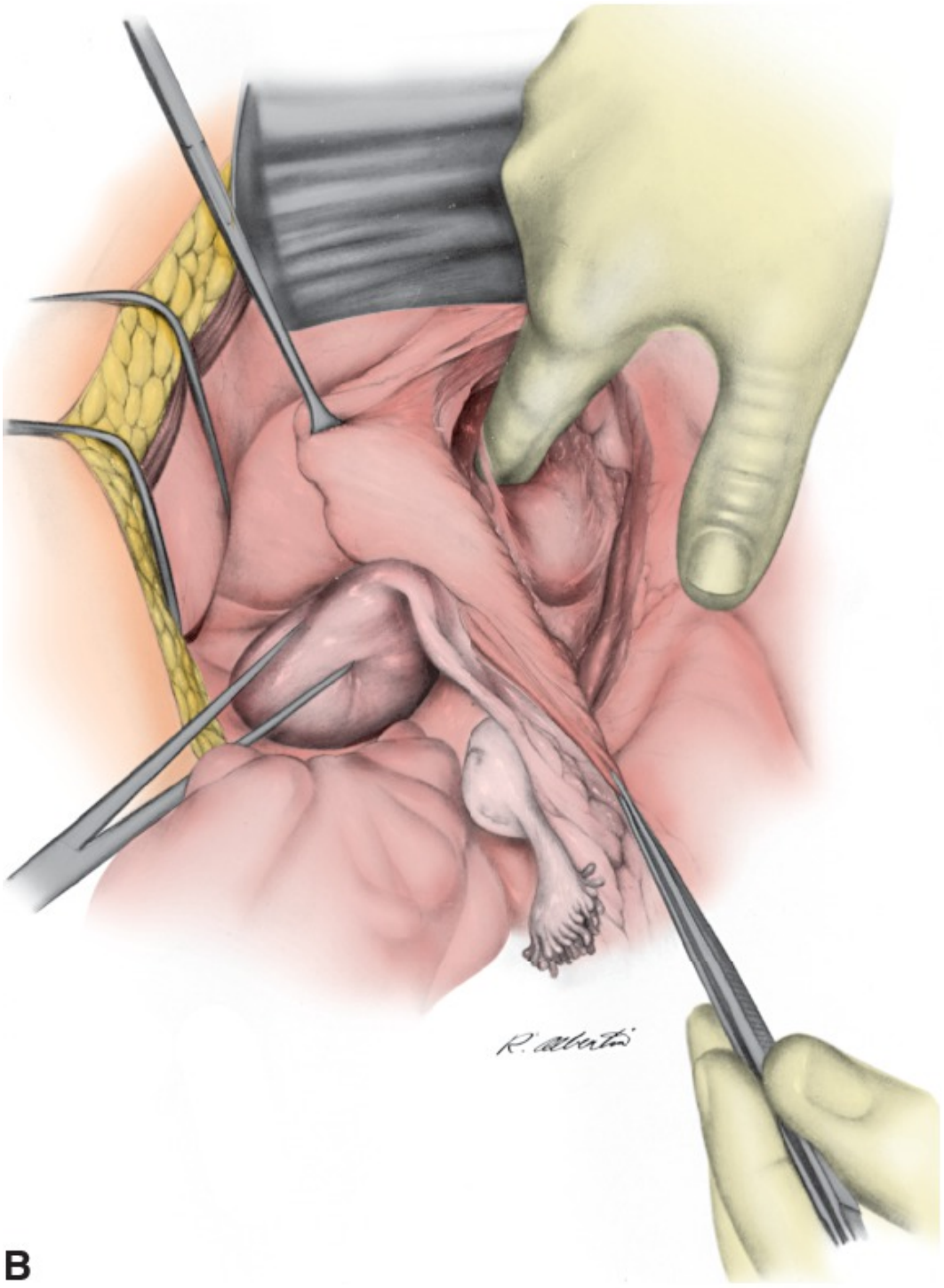


B

**FIGURE 28.10 A.** Opening the anterior leaf of the broad ligament after ligation of the right round ligament and infundibulopelvic

ligament. **B.** Development of paravesical space.

The pararectal space lies beneath the pelvic peritoneum and extends between the cardinal ligament laterally and the uterosacral ligament medially (**FIG. 28.11A**). By retracting the infundibulopelvic ligament and displacing the uterus medially, the uterosacral ligament is placed on a stretch, and the pararectal space is widened. Dissection in the pararectal space is much more precarious than in the paravesical space, and unskilled dissection here is frequently associated with troublesome bleeding. The medial border of the fossa is bounded by the uterosacral ligament and rectum; the lateral border is formed superiorly by the piriformis muscle and inferiorly by the levator muscle. The sacrum forms the posterior margin of the space, and the ureter is attached to the peritoneum along the roof of the space before entering the medial aspect of the cardinal ligament. The medial leaf of the broad ligament is incised, and the ureter is freed from the peritoneum. The hypogastric artery and vein are located in the deeper aspect of the pararectal space along the levator ani muscle. The cardinal ligament forms the caudal and lateral borders of this important area. Care must be taken to avoid unnecessary damage to small veins deep in this fossa. Further development of the space then changes to an inferior and caudad direction lateral to the rectum. With the paravesical and pararectal spaces dissected (**FIG. 28.11B**), the pelvic floor and cardinal ligament can easily be identified and palpated. In the absence of demonstrable tumor extension, the case is considered operable.

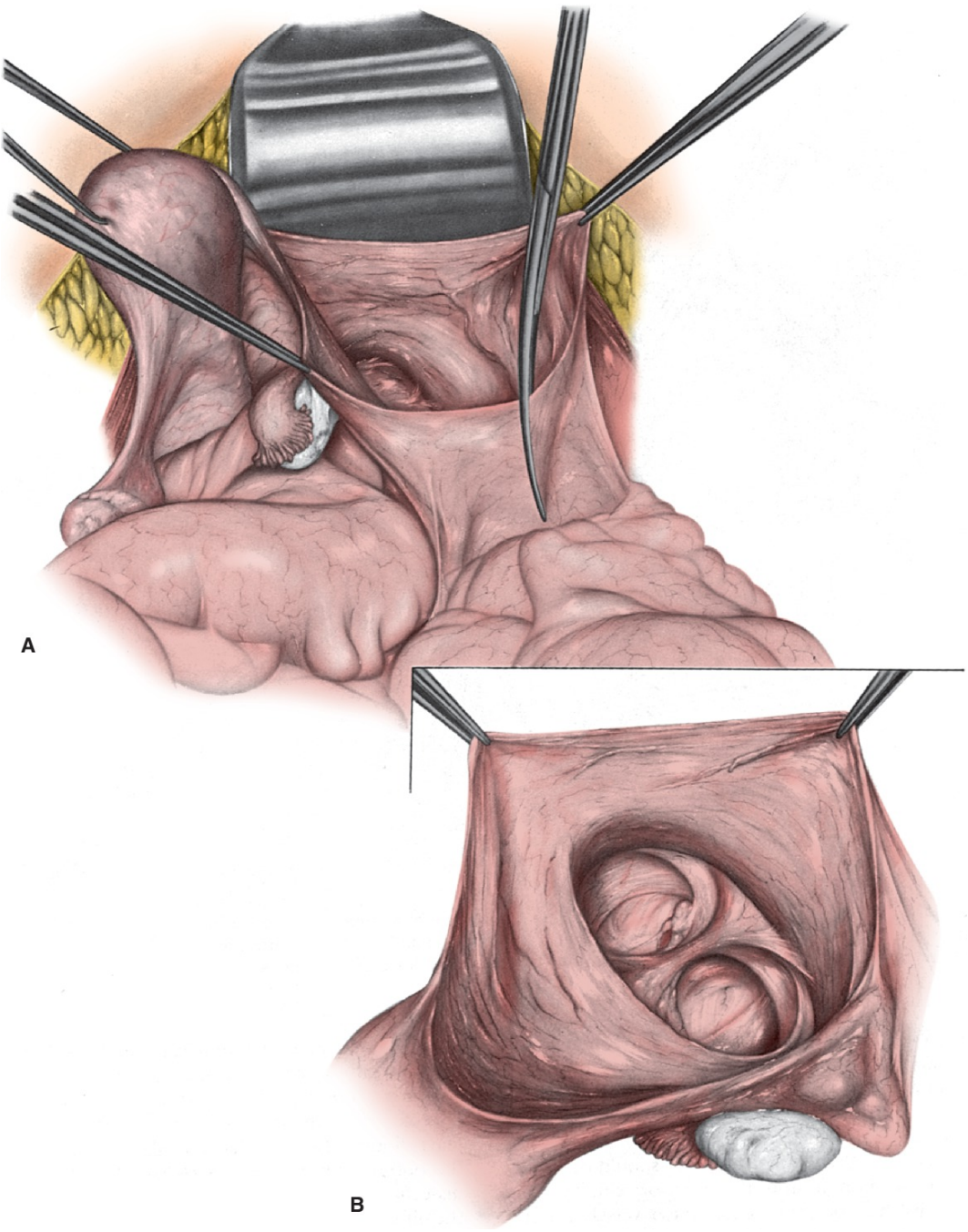



**FIGURE 28.11** **A.** Extending the incision in the anterior leaf of the broad ligament in a cephalic direction along the lateral margin of the right infundibulopelvic ligament. **B.** Paravesical and pararectal fossae, with

intervening base of broad ligament attached to pelvic floor and lateral pelvic wall.

# Dissection of Hypogastric Artery, Uterine Artery, Bladder, and Ureter

The hypogastric artery is dissected with identification of the visceral branches of the anterior trunk, which include the uterine, superior, middle, and inferior vesical, and the vaginal and middle hemorrhoidal arteries. The anterior division of the hypogastric artery continues along the paravesical fossa to become the obliterated lateral umbilical ligament beneath the anterior abdominal wall. If the superior vesical artery is damaged, it can be ligated without serious compromise to the blood supply of the bladder. At this point, the uterine artery is ligated at its origin from the hypogastric artery. Some authors have reported that a more adequate central dissection is achieved by ligating the anterior division of the hypogastric artery just distal to the point of origin of its posterior division, rather than ligating the uterine artery individually. Whichever vessel is chosen, after ligation, the distal branches traversing the cardinal ligament are removed with the specimen. No attempt is made to remove the hypogastric vein. The other, adjacent veins should be ligated to avoid brisk bleeding in this area. The bladder is then reflected off the lower uterine segment by incising the bladder peritoneum from its attachment to the uterus. The fascial adhesions of the base of the bladder are released from the cervix and upper vagina by electrocautery or sharp scissors dissection, and the vesicocervical space is developed inferiorly and laterally. The ureter tunnels between the anterior fascial bundles of the base of the broad ligament, commonly called the vesicouterine ligament. This fascial tunnel is carefully opened, as shown in **FIGURE 28.12A**. The uterine artery and vein course along the fascial roof of this ligament. As shown in **FIGURE 28.12B**, the anterior sheath of the vesicouterine ligament is opened by doubly clamping and incising this tissue. Each of the fascial bundles is ligated to control bleeding, and the ureter is dissected free of its attachment to the posterior leaf of the vesicouterine ligament. As with the pelvic vessels, care must be taken to prevent damage to the adventitia and muscular wall of the ureter, which contain nutrient vessels from the collateral circulation. If

the blood supply to the ureter is compromised by thrombosis or trauma to the veins, the risk of fistula formation increases.

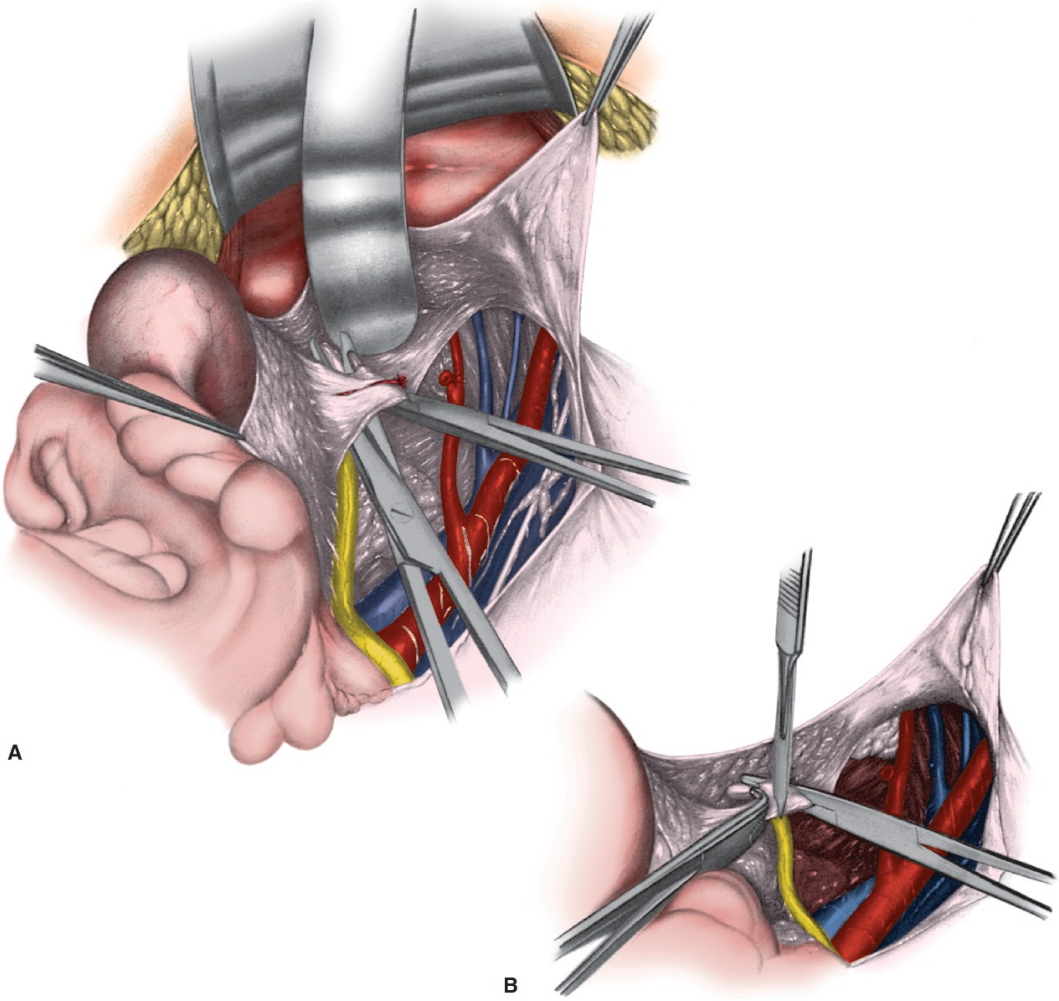



**FIGURE 28.12** **A.** Metzenbaum scissors inserted above the ureter in the vesicouterine ligament or ureteral tunnel of the broad ligament. Note ligated uterine artery in anterior fascial sheath of tunnel. **B.** Roof of tunnel is opened between clamps.

# Dissection of Cardinal Ligament

The base of the broad ligament (the cardinal ligament) can then be excised from its attachment at the lateral pelvic wall (**FIG. 28.13A** and **B**). If serious bleeding occurs in this region due to trauma to the pelvic floor veins, hemostatic control is best obtained by firm packing of the pelvis and by shifting the dissection temporarily to the opposite side.

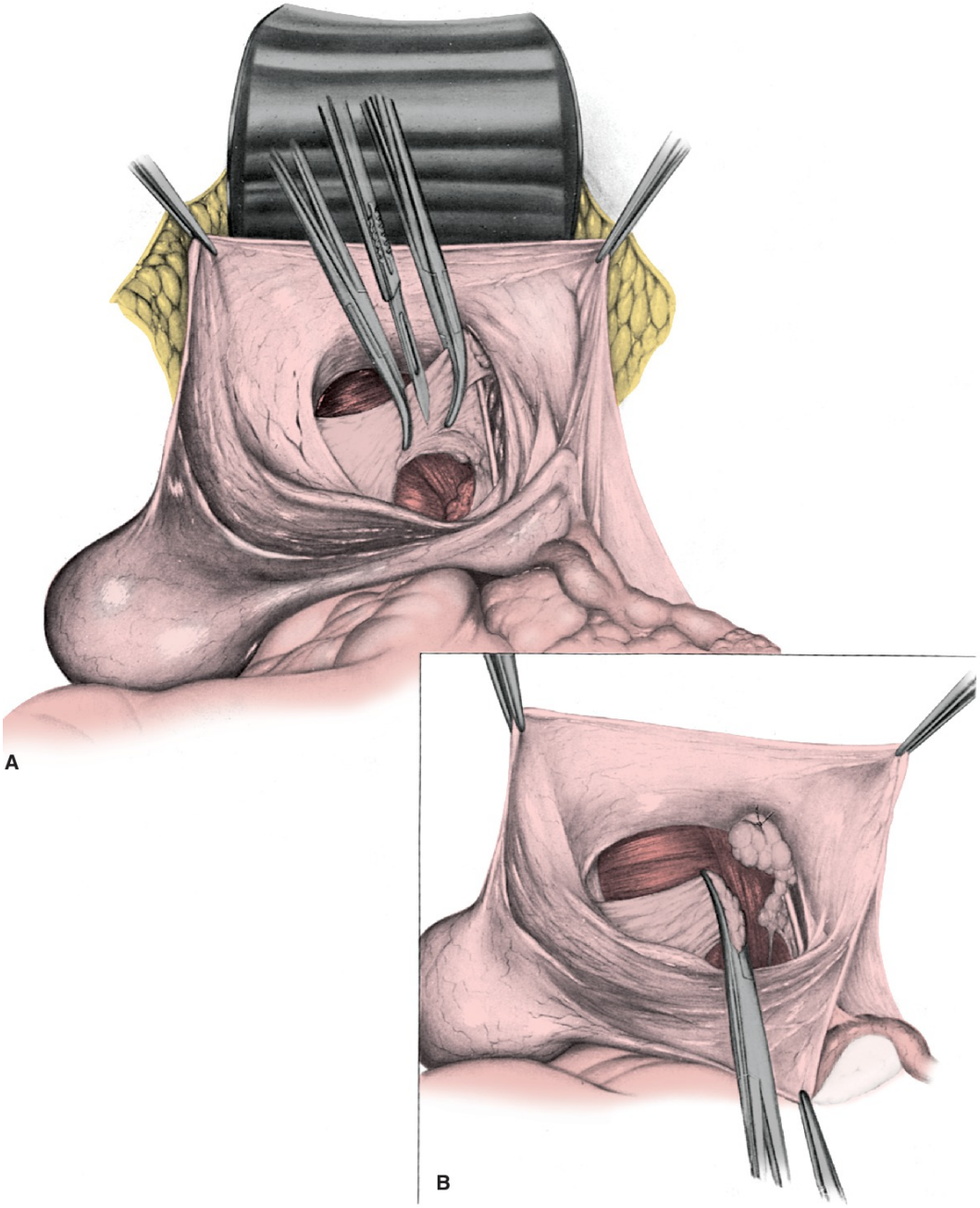



**FIGURE 28.13** **A.** Clamping and incision of lateral portion of cardinal ligament adjacent to the lateral pelvic wall. **B.** Excised ligament showing pelvic floor and levator muscles. Dissected obturator nerve is seen in obturator space.

The uterosacral ligaments originate from a posterolateral position on the cervix, where they are thickest, and run posteriorly to the anterolateral aspect of the rectum. As the ligaments approach the rectum, they broaden so that they have a wider attachment to the rectum than to the cervix. The uterosacral ligaments are stretched by drawing the uterus forward. The peritoneal reflection of the cul-de-sac of Douglas is then incised, leaving a small segment of peritoneum attached to the anterior surface of the rectum. Care must be taken to avoid injury to the ureters, though separation of the ureters from the medial leaf of the broad ligament will aid in this dissection (**FIG. 28.14A**). The rectovaginal space is opened and deepened (**FIG. 28.14B**). This procedure separates the posterior reflection of the endopelvic fascia from the lateral wall of the rectum, which includes the more superficial uterosacral ligaments. The entire fascial bundle of the uterosacral ligament is identified, clamped as far posteriorly and close to the anterior rectal wall as planned (traditionally as close to the rectum as possible), and cut and ligated (**FIG. 28.14C**). Continuation of this plane of dissection along the posterior endopelvic fascia frees the posterior aspect of the cervix from the pelvic floor. Trimbos and colleagues have described a “nerve-sparing” radical hysterectomy that involves a less radical dissection of the uterosacral ligament, which reduces the incidence of bladder dysfunction without compromising cure rates.

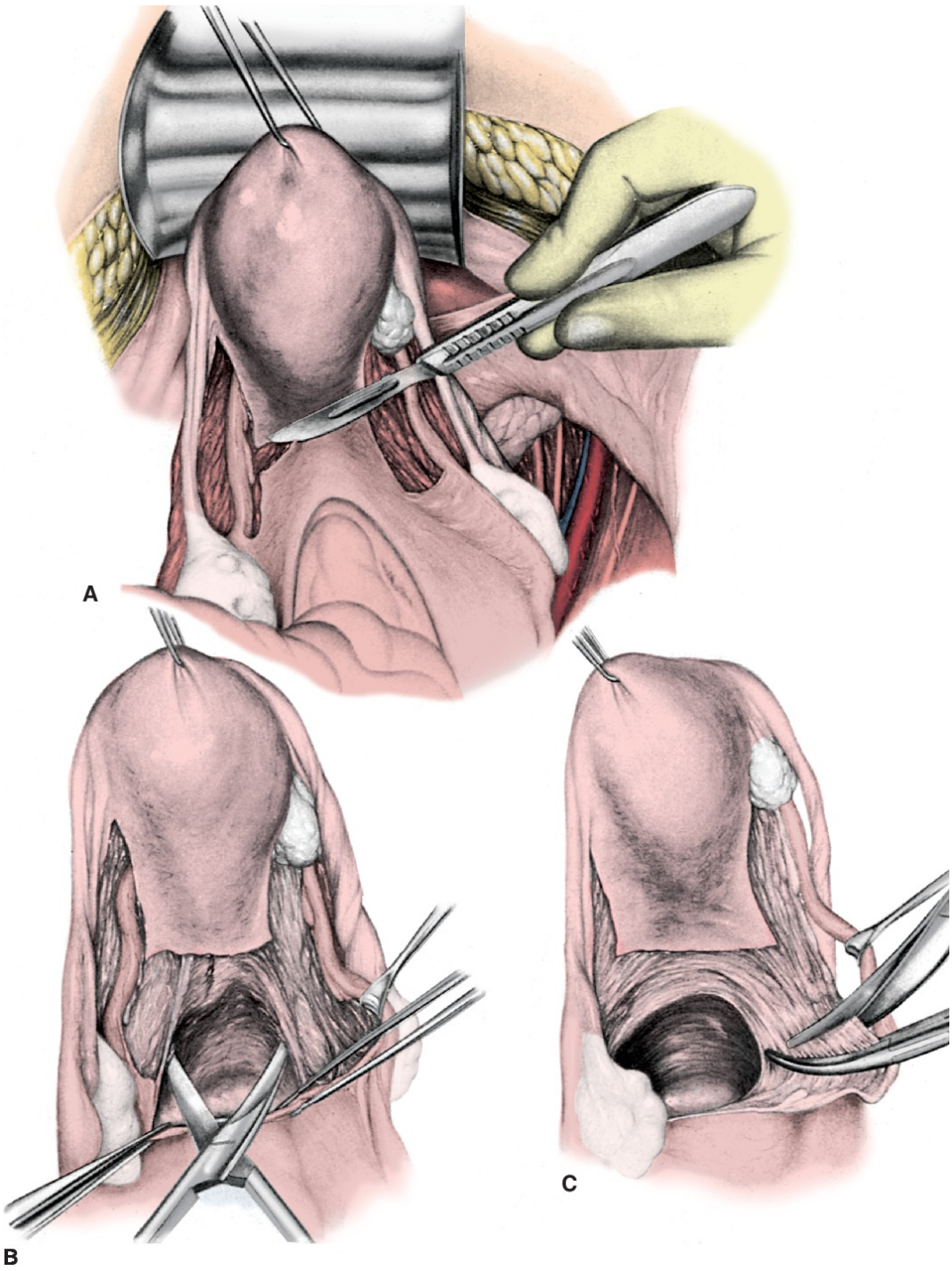



**FIGURE 28.14** **A.** Cutting the cul-de-sac peritoneum as it reflects onto the rectum. Ureters course laterally, devoid of peritoneum. **B.** Dissection of the rectovaginal septum with

development of rectal stalks (uterosacral ligaments). **C.** Clamping the uterosacral ligament. The ureter is gently retracted to avoid trauma.

It is important to dissect the paravaginal fascia to obtain all the microlymphatic channels that communicate between the cervix and upper vagina. The bladder is then dissected further from the upper portion of the vagina by sharp and blunt dissection, making certain to avoid trauma to the blood supply of this organ. Sharp rather than blunt dissection should be performed to free the base of the bladder from the anterior vagina and to avoid forceful tearing of the blood vessels and bladder musculature. The specimen is then removed by dividing the vagina (**FIG. 28.15**; **VIDEO 28.1**). After a Wertheim clamp is placed on the vagina, proximal to the location of the colpotomy, to control any spillage of tumor.

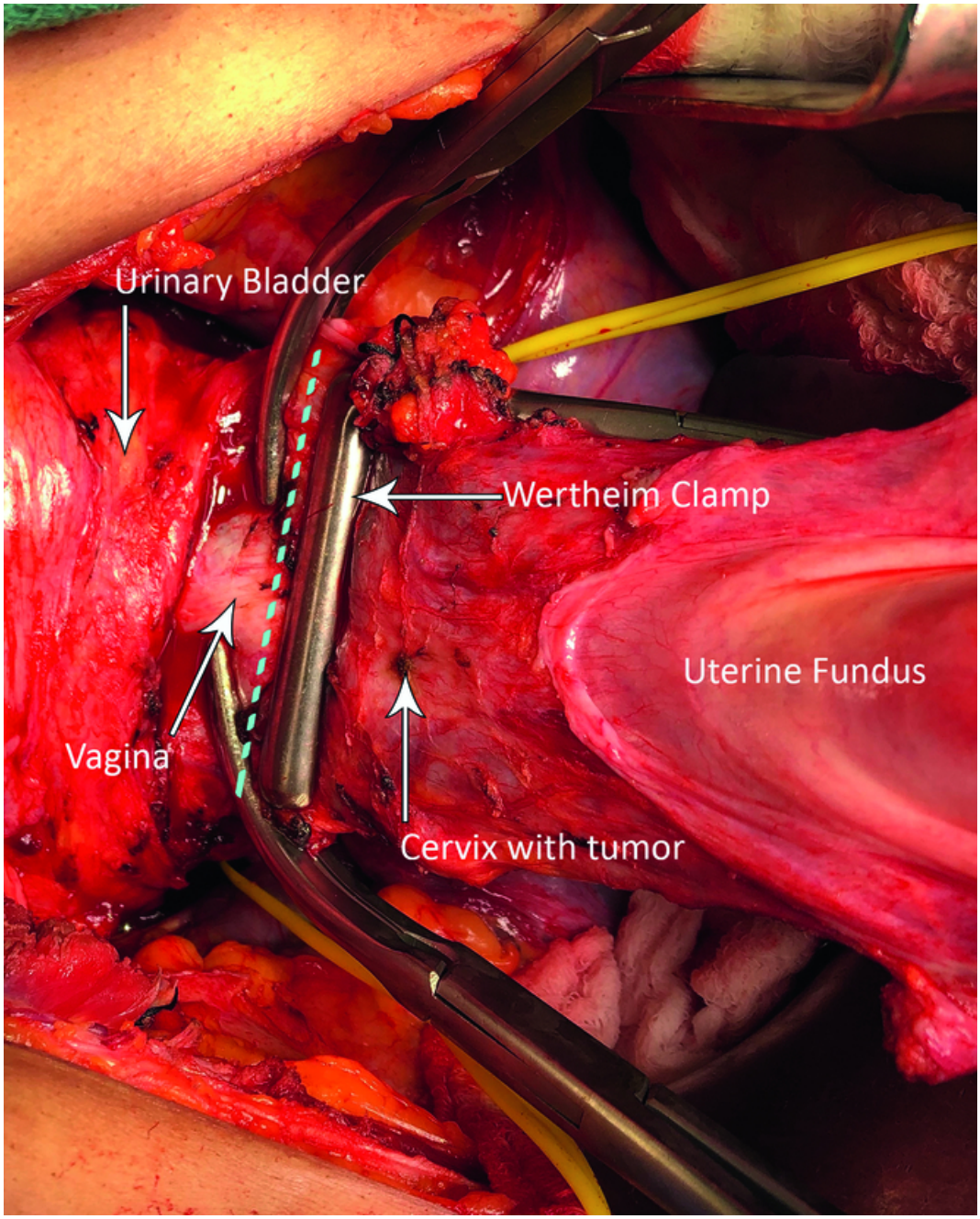



**FIGURE 28.15** After clamping and ligating paravaginal tissues laterally, an incision (indicated by *blue line*) is made in the vagina several centimeters below the cervix. A Wertheim clamp is placed above this to prevent spillage of tumor.

## BOX 28.1 STEPS IN THE PROCEDURE

### Radical Hysterectomy

- Evaluate the abdomen and pelvis for evidence of metastatic disease.
- Develop the paravesical spaces.
- Develop the pararectal spaces.
- Dissect the ureter off the medial leaf of the broad ligament.
- Dissect the internal iliac artery and identify the uterine artery.
- Identify the deep uterine vein and hypogastric nerve. Ligate and divide the uterine artery and superficial uterine vein.
- Incise the bladder peritoneum from its attachment with the uterus and reflect the bladder off the lower uterine segment.
- The ureteral “tunnel” is dissected, and the anterior sheath of the vesicouterine ligament is opened.
- The base of the broad ligament is excised from its attachment at the lateral pelvic wall.
- The rectovaginal space is developed.
- The uterosacral ligaments are divided avoiding the hypogastric nerve plexus.
- The vesicovaginal space is further dissected. A Wertheim clamp is placed on the vagina proximal to the desired level of colpotomy to prevent spillage of tumor, and a colpotomy is made caudal to the Wertheim clamp.
- The vagina is divided at the desired level.
- The vagina is closed with a delayed absorbable suture.

## Vaginal Closure

The vagina is closed using a delayed absorbable suture. The remaining vagina, which has been shortened by 2-3 cm, is well supported by its attachments to the levator ani muscles and urogenital diaphragm. The utility of placing pelvic drains has been studied extensively and no benefit has been identified. No attempt is made to suspend the ureters to the hypogastric artery, as suggested by Green et al., or to place the terminal ureter on the inside of the peritoneal surface, as recommended by Novak. Furthermore, there appears to be no benefit to approximating the peritoneum with pelvic closure as described by Symmonds and Pratt.

# Ovarian Transposition

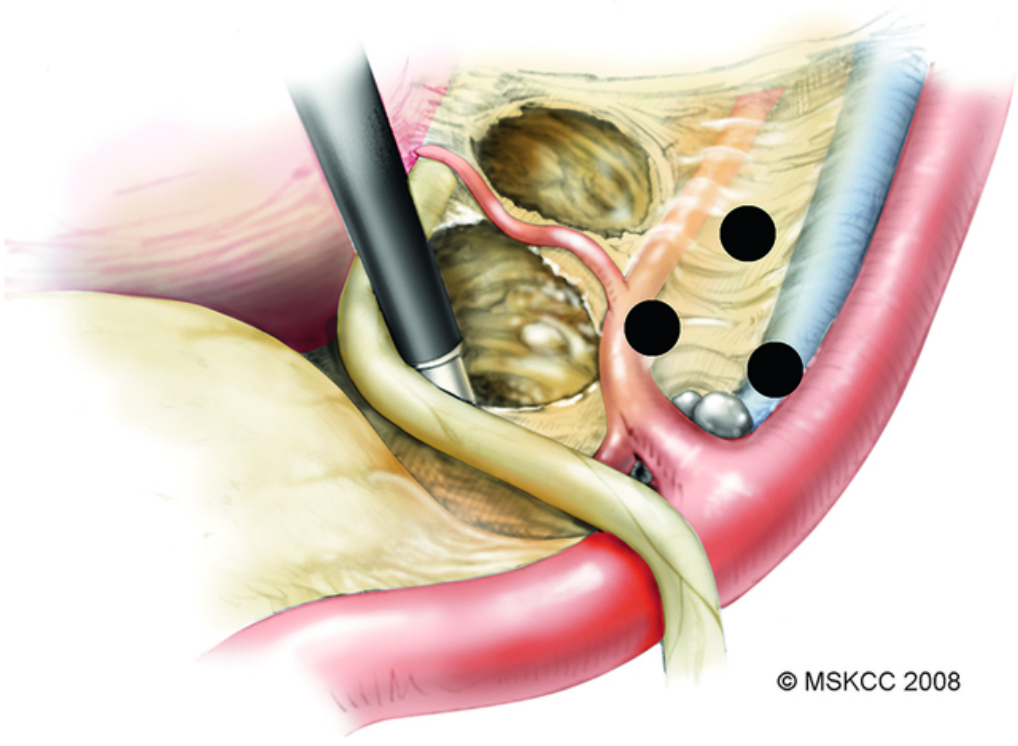
Ovarian transposition is considered when there is a high likelihood of pelvic radiation and the patient desires to retain ovarian function. We do not routinely perform ovarian transposition following radical hysterectomy, but the technique is described here. If the ovaries are to be transposed out of the pelvis, a tunnel is dissected beneath the peritoneum laterally and superiorly toward each lateral gutter. An incision in the peritoneum is made as high as possible at the top of the tunnel. The ovaries are guided through the tunnel and through the incision at the top of the tunnel, making certain that the ovarian vessels in the infundibulopelvic ligament are not twisted. Permanent suture material is used to suture the ovarian pedicle as high as possible to the peritoneum and underlying muscle. Two large metal clips are also placed across the pedicle to later identify the location of the ovaries with an abdominal radiograph.

# Lymphadenectomy

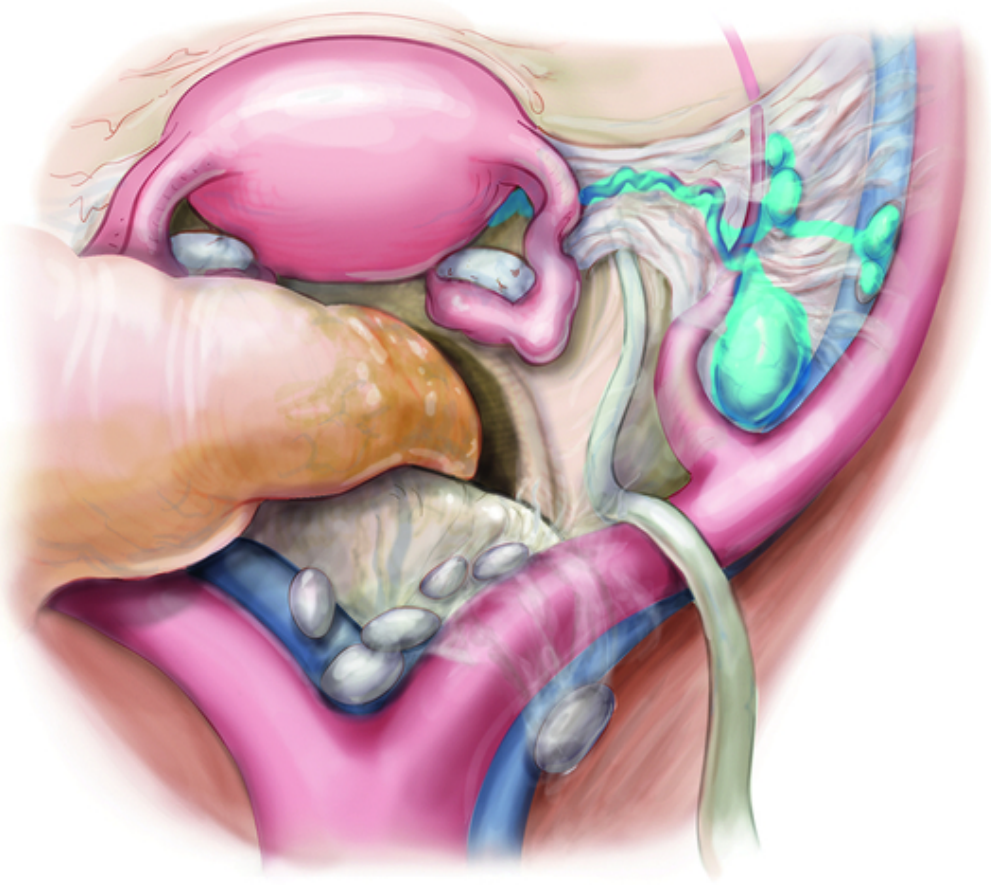
Traditionally, lymphadenectomy was performed at the time of abdominal radical hysterectomy to diagnose metastatic lymph nodes (which would determine subsequent adjuvant treatment) and because it was felt that lymphadenectomy was helpful in achieving an adequate central dissection around the cervical tumor, the most important part of the operation. However, full lymphadenectomy has been associated with both short- and long-term complications,

including infection, nerve injury, vascular injury, and lower extremity lymphedema. Moreover, in women with operable cervical cancer, the rate of lymph node metastasis is between 1% and 15%, meaning that 85%-99% of women who undergo pelvic lymphadenectomy at the time of cervical cancer surgery may not benefit from full lymph node dissection but are nevertheless subjected to its risks.

SLN biopsy is widely utilized for staging breast cancer, melanoma, vulvar cancer, and others. The benefits of SLN mapping and biopsy include improved detection of microscopic disease and reduction of the side effects of full lymphadenectomy. SLN biopsy was first described for cervical cancer by Echt in 1999. Since then, numerous groups have reported their experience with SLN mapping and biopsy. The use of SLN biopsy has also been included in the most recent NCCN guidelines and is an option for lymph node assessment in patients with stage IA1 with LVSI, stage IA2, stage IB1, and stage IIA1 disease. See Chapter 27 for detailed description of lymphadenectomy (**FIG. 28.16**).




**A**



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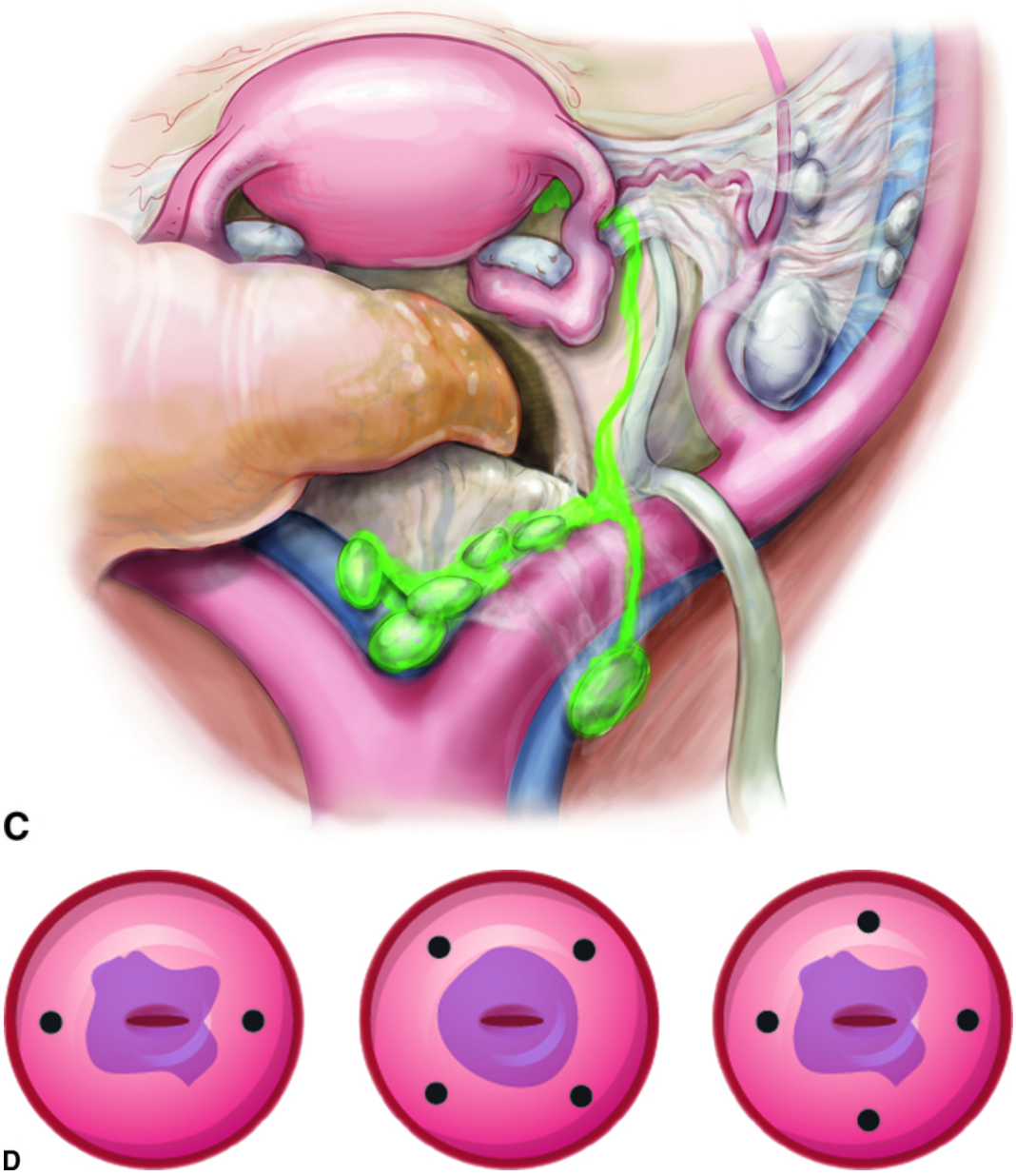


**FIGURE 28.16** **A.** Most common sites of involved SLN nodes in women with cervical cancer. **B.** Following a cervical injection of dye, the most common location of SLN is medial to the external iliac, ventral to the hypogastric, and superior part of the obturator nodes. **C.** Less common SLN drainage and

location. If the lymphatic trunks are following the mesoureter look for the SLN in the common iliac presacral region. **D.** Most common injection sites for cervical neoplasia. (Copyright © MSKCC 2008, Memorial Sloan-Kettering Cancer Center, Memorial Hospital for Cancer and Allied Diseases, and Sloan-Kettering Institute for Cancer Research, each in New York, NY. All rights reserved. Republished with permission.)

# POSTOPERATIVE COMPLICATIONS

## Urologic Complications

A traditional radical hysterectomy substantially denervates the bladder and upper urethra; the more extensive the dissection, the greater the degree of interference with their function. Therefore, a nerve-sparing resection has become popular.

During a standard radical hysterectomy, parasympathetic and sympathetic nerve fibers to and from the bladder and urethra are removed, along with paracervical, paravaginal, and cardinal ligament tissues. The bladder may initially be hypertonic, with decreased bladder capacity, increased resting pressure, and increased residual urine volume. Many patients have difficulty initiating micturition and experience a loss of sensation of bladder fullness. All patients who have undergone standard hysterectomy will have some degree of bladder dysfunction and up to 50% of patients will have significant bladder dysfunction after conventional radical hysterectomy.

### *Bladder Management*

Approaches for managing the postoperative bladder vary widely. Duration of catheter drainage, suprapubic or transurethral drainage, the value of self-catheterization, and the value of cystometric studies have all been debated as described by Bandy et al. These authors also found that patients receiving postoperative adjunctive pelvic radiation had significantly more contracted and unstable bladders than patients treated with surgery alone. Proper management of the bladder in the first few weeks after surgery is essential, to avoid overdistention.

In cases of nerve-sparing radical hysterectomy, surgeons have recommended early catheter removal (24-72 hours after surgery) with reports of normal voiding function. After removal of the catheter, postvoid residuals are checked with a bladder ultrasound scan (transurethral catheterization may also be used). If the postvoid residual volume is below 50-75 mL and the volume of urine spontaneously voided is greater than the postvoid residual, then the patient can leave the hospital without an indwelling catheter. Allowing the bladder to overdistend, especially in the early postoperative recovery period, can result in a flaccid bladder secondary to stretching and decompensation of the detrusor muscle, prolongation of bladder dysfunction with high residual urine volumes, and the likelihood of urinary infections. Patients who have unacceptable postvoid residuals are best managed with intermittent self-catheterization or prolonged indwelling catheter drainage for several weeks, before attempting removal. If a serious episode of overdistention of the bladder occurs, continuous indwelling catheter drainage should be reinstituted, sometimes for 1-2 weeks, plans to reassess bladder function.

In the absence of prior pelvic irradiation, bladder ischemia and vesicovaginal fistula are infrequent complications. Vesicovaginal fistulae occur in <1% of patients. Nearly one-third of urinary tract fistulae following surgery heal spontaneously, compared with none if adjuvant radiation therapy is given.

## *Ureteral Management*

Sampson, working with Clark at Johns Hopkins University, recognized that injury to the ureter was the most serious problem associated with the procedure. His publications on ureteral anatomy and blood supply and the relation between the ureter and gynecologic disease are classics and remain pertinent today. Devascularization and ischemic necrosis of the wall of the terminal ureter has proven to be one of the most serious sequelae, as reported by Wertheim. Meigs reported a 12.5% rate of significant ureteral complications, including an 8.5% incidence of ureterovaginal fistulae and a 4% incidence of ureteral stricture.

For many years, gynecologic surgeons have attempted to lower the rate of ureteral complications using special approaches. Surgeons in Yugoslavia reduced the incidence of ureteral fistulae to 2% after primary radical surgery by placing the dissected pelvic ureter on the inside (peritoneal surface) of the pelvic peritoneum and preserving the lateral mesentery to the terminal ureter. Green et al. suggested that the terminal ureter be lifted out of the accumulated fluid in the retroperitoneal space by suturing it to the obliterated hypogastric artery. Given a normal, nonirradiated ureter, we believe that the incidence of ureteral fistulae and permanent stenosis can be kept below 1% with meticulous intraoperative management by a technically skillful surgeon who can prevent vascular trauma to the periureteral sheath and injury to the muscularis of the ureter.

## Venous Thrombosis and Pulmonary Embolus

Patients who undergo radical pelvic surgery fulfill the components of Virchow triad and are at high risk for the development of venous thrombosis of the lower extremities and thromboembolic phenomena. Factors such as postoperative alteration of blood coagulation, trauma to the vein wall, and venous stasis are recognizable features of this type of surgery. Pelvic lymphadenectomy invariably produces some trauma to the vein wall during mobilization of the vessel and resection of the adherent lymphatic tissue. Prolonged immobilization of the lower extremities

during a lengthy operative procedure is responsible for intraoperative venous stasis and clot formation. Postoperative thrombosis of the lower extremity occurs as a result of the surgical procedure in more than 50% of cases.

To decrease the frequency of this complication, perioperative dose of 5000 U Heparin is administered followed by low molecular weight heparin until patients are mobile. Sequential pneumatic compression devices are placed in the operation room and use is continued while patients are in bed postoperatively.

# Neuropathy

A review by Hoffman et al. found that nerve injury as a complication of radical hysterectomy occurred infrequently. The nerves at risk for injury include the femoral, obturator, peroneal, sciatic, genitofemoral, ilioinguinal, iliohypogastric, lateral femoral cutaneous, and pudendal nerves. Awareness of the anatomic location of these nerves in the operative field, careful surgical technique in dissection and securing hemostasis, careful placement of self-retaining retractors, and careful positioning of patients in stirrups prevent most nerve injuries.

Injury to the obturator nerve can lead to difficulty with adduction of the lower extremity. Obturator nerve injuries are the most common neurologic injuries, and they occur most frequently during removal of the obturator lymph nodes from the obturator fossa. If the nerve is transected, it can be repaired as described by Vasilev or with neurosurgery consultation. Fortunately, most nerve injuries are not associated with serious or permanent disability.

# Rectal Dysfunction

Acute and chronic rectal dysfunction may occur following radical hysterectomy. This is less frequently reported than bladder dysfunction. Rectal dysfunction is characterized by difficulty with defecation, loss of defecation urge, and constipation. Barnes et al. reported that postoperative anorectal manometry was abnormal in all patients undergoing radial hysterectomy due to disruption of the spinal reflex arcs controlling rectal emptying, possibly secondary to

partial denervation of the rectum. Nerve-sparing radical surgery will hopefully abbreviate and reduce the incidence of this complication.

## Infection

Historically, patients were treated with antibiotics only if postoperative infection occurred. However, antibiotic prophylaxis has been associated with decreased febrile morbidity and decreased rates of serious infection in women undergoing radical abdominal hysterectomy. Perioperative prophylactic antibiotics are administered when radical hysterectomy is planned. When secondary infection occurs despite the use of prophylactic antibiotics, appropriate cultures are obtained, and bacteria-specific antibiotic therapy is selected along with drainage of pelvic abscesses.

# PELVIC EXENTERATION

The majority of cervical cancer–related deaths occur because of recurrent or persistent disease in the pelvis. In women who have persistent or recurrent cervical cancer shortly after primary treatment, salvage surgery or radiation may be considered, when appropriate. It is essential that biopsy be performed to confirm the presence of disease, particularly in women treated with radiation, because radiation changes may last for months after completion and be interpreted as recurrent disease. Additionally, imaging including MRI, CT, or PET may be useful in determining location and extent of disease.

The mainstay of treatment for centrally recurrent cervical cancer occurring after initial surgery or radiation therapy has been pelvic exenteration. Pelvic exenteration was first described by Brunschwig in 1948. It is an ultraradical procedure that includes the en bloc removal of the bladder, rectum, and vagina inclusive of the tumor. Variations of total pelvic exenteration include anterior exenteration (where the rectum is spared) and posterior exenteration (where the lower urinary tract is spared). Pelvic exenteration can be additionally divided into the supralevator approach, in which much of the pelvic floor is retained, and total infralevator exenteration, in which the

levator ani muscles are divided and all or most of the vulva is removed.

Women who undergo pelvic exenteration with negative margins have a cure rate of ~50%. However, when the surgical margins are involved, long-term survival is only 10%. Patients are considered for exenteration if they have a centrally located recurrence with no evidence of metastatic disease. Preoperative workup includes biopsy and imaging to confirm recurrence and to evaluate for any metastatic disease. Even among women who have a negative metastatic workup prior to surgery, one-third will be found to have unresectable disease at the time of surgical exploration, due to either metastases or pelvic sidewall involvement.

In addition to clinical characteristics related to the patient's disease, factors such as age, performance status, and comorbidities should be considered when considering pelvic exenteration. Given the radical nature of the surgery, appropriate medical and cardiac workup should be undertaken to ensure a patient's ability to tolerate the procedure. In women who are overweight or obese, operative times are longer, and there are higher rates of wound complications. Rates of postoperative complications are high following exenteration and range from 50% to 100%. Perioperative mortality of pelvic exenteration is reported from 2% to 18%.

# Positioning and Preparation

Careful discussion of the extent of dissection should be undertaken with the anesthesia team before surgery, so that adequate resuscitative equipment and blood products are available during the procedure. Three to six units of blood, as well as platelets and fresh frozen plasma should be readily available. Adequate vascular access should be obtained to allow for a rapid, large-volume resuscitation. Placement of sequential compression devices and pharmacologic deep venous thrombosis prophylaxis should be utilized. Prophylactic antibiotics are given.

Patients are placed in the dorsal lithotomy position to allow access to both the perineum and the abdomen. As in radical hysterectomy, care must be taken to avoid nervous or vascular

trauma to the legs. The patient is prepped and draped from the level of the chest to the midthigh to allow access to the abdomen and perineum. Two teams can work simultaneously, abdominally and during the perineal phase, to decrease operative time.

## Surgical Approach

If a total exenteration with perineal phase is planned, the anus is sewn shut prior to abdominal incision. Access to the abdomen is achieved throught laparotomy, laparoscopy, or a robotic approach. Regardless of the approach, the steps of the procedure remain the same. The abdomen and pelvis are evaluated for evidence of metastatic disease, and biopsies of suspicious nodules are sent for frozen section as needed.

If no metastatic disease is identified, the procedure begins by opening pelvic sidewalls bilaterally. The avascular spaces of the pelvis are developed. The peritoneum lateral to the medial umbilical ligament will allow access to the paravesical space. The pararectal space is located between the internal iliac artery and the ureter. A detailed description of development of this space is included in the section on radical hysterectomy. The development of this space is carried posteriorly to the sacrum; the internal iliac vessels are identified; and the anterior division of the internal iliac arteries may be ligated depending on the planned extent of the dissection.

The ureters are skeletonized, clipped, and transected near the level of the pelvic brim. Care must be taken to identify a healthy segment of ureter that has not been previously radiated, to optimize the urinary reconstruction.

The sigmoid colon is mobilized and transected with a surgical stapler at the level of the pelvic brim. Blood supply to the left colon, including the left colic artery, can be preserved. The distal rectosigmoid is placed on traction anteriorly at this point, and the presacral space is identified. The mesorectum, including the superior rectal artery, is ligated and divided. In the case of a total exenteration with a perineal phase, the dissection is carried down to the coccyx; however, if a supralevator exenteration is planned, the dissection is planned to allow for sufficient tumor margin. If needed, the entire

rectum may be removed and a coloanal anastomosis performed but preserving as much rectum as can be safely retained (even 1-2 cm) will improve bowel function and reduce the likelihood of rectal anastomotic fistula.

Attention is then turned anteriorly, and the space of Retzius is developed. This is accomplished by continuing the dissection of the paravesical space medially until the bladder is encountered. The bladder is dissected from the posterior surface of the pubic symphysis. Care should be taken to dissect near the symphysis to avoid bleeding from the plexus of Santorini. If a supralevator dissection is planned, the urinary catheter is removed, and the urethra is ligated and divided. If a perineal phase is planned, the urethra is dissected off the pubic bone.

With the completion of abdominopelvic dissection, the perineal phase (if planned) is initiated. The surgeon or a separate surgical team outlines the planned area of resection, and the perineum is incised. The dissection is carried through the underlying subcutaneous tissue and musculature until the incision meets the pelvic dissection. Once all attachments are freed, the specimen is removed through the perineum.

Reconstruction of the pelvis includes a combination of urinary and bowel diversion, as well as attention to the pelvic defect. In a total exenteration with perineal phase, the perineal defect is large, and primary closure is frequently associated with dehiscence and hernia. For this reason, myocutaneous flaps, such as gracilis and rectus abdominis flaps, are commonly used for reconstruction. In patients who have undergone supralevator exenteration, the myocutaneous flaps may also be used to create a neovagina.

Urinary and bowel diversions are planned based on the type of resection performed and the preference of the patient and the surgeon. Incontinent urinary diversions such as an ileal conduit, or continent urinary diversions, are reconstructive options. Large bowel diversion with an end colostomy is commonly planned for patients who have undergone total exenteration. The “double-barreled wet colostomy” utilizes a sigmoid loop colostomy where urine collects in a distal sigmoid limb, separate from the functional colonic limb. In this type of diversion, stool and urine are expelled into the same bag.

Operative time for exenterations may be as long as 8 hours, with a median blood loss of 3 liters. Postoperatively, patients are admitted for 2-3 weeks and often require intensive care admission in the immediate postoperative period. The risk of perioperative mortality is 5%-10%, and the risk of complication approaches 50%. Infection (40%), bowel obstruction (22%), and fistula (23%) are common postsurgical complications.

## BOX 28.2 STEPS IN THE PROCEDURE

### Total Pelvic Exenteration

- Evaluate the abdomen and pelvis for metastatic disease or sidewall involvement.
- The paravesical spaces are developed.
- The pararectal spaces are developed.
- The internal iliac vessels are identified, and the anterior division is ligated as needed.
- The ureters are skeletonized and divided.
- The sigmoid colon is mobilized and divided.
- The mesorectum is divided to the level of the coccyx.
- The space of Retzius is developed, and the bladder is dissected from the pubic symphysis.
- The perineal phase a performed by incising the perineum to meet the pelvic dissection.
- The specimen is removed, and urinary and bowel reconstructions are performed. The pelvic defect is reconstructed.

# SUMMARY

Since the original description of radical hysterectomy, many improvements have been made in operative technique and lymph node assessment. The incidence of complications after radical hysterectomy has decreased over the past 75 years, and survival rates have increased. The operation has achieved its peak clinical usefulness during this period and is now considered the principal method of treatment for early invasive carcinoma of the cervix. As more is understood about the nature of cervical cancer, the radicality of surgery has been tailored even further, allowing for fertility-sparing options and reduction in complication rates. Additionally, SLN biopsy has reduced the surgical morbidity of lymphadenectomy.

# KEY POINTS

- Cancer of the cervix is predominantly HPV related and the majority are squamous cell carcinomas. Adenocarcinoma is increasingly common in many practices and now accounts for up to 20%-50% of cancers. Adenosquamous, clear cell, and small cell neuroendocrine carcinomas occur infrequently.
- In the United States, most women with FIGO 2018 stage IB1, IB2, and IIA1 cervical cancer are treated with radical surgery. Patients with larger, higher-stage tumors are usually treated with definitive chemoradiation therapy. Patients who are poor surgical risks are also usually treated with radiation with chemosensitization. Bladder and rectal dysfunction and, rarely, fistulae occur with both surgery and radiation. Surgical complications tend to occur in the perioperative period, whereas complications and side effects from radiation are often delayed and long-lasting.
- Lymph node assessment can be performed either by an SLN biopsy or by lymphadenectomy. If SLN biopsy is planned, it should be undertaken based on the NCCN SLN algorithm.
- A careful and thorough staging workup should be undertaken. This evaluation of the extent of disease is crucial to treatment planning and prognosis. Imaging modalities such as CT, MRI,

and PET scans can provide very important information to guide treatment and are included in the most recent FIGO Staging.

- In patients who desire fertility-sparing treatment, cervical conization (with a negative margin) alone for patients with stage IA1 without LVSI is acceptable. Conization with SLN biopsy is acceptable for stage IA1 disease with LVSI, stage IA2 and, in very select cases, stage IB1 disease. In some women with stage IA2 or IB1 or IB2 disease, radical trachelectomy with SLN biopsy or pelvic lymphadenectomy can be offered.
- In patients with stage IA1 disease with no LVSI, who are not desirous of fertility, simple hysterectomy is appropriate. For women with stage IA1 with LVSI, or stage IA2, we recommend modified radical hysterectomy (type B) with pelvic lymphadenectomy or SLN mapping. Women with stage IB1 or IIA1 disease should undergo type C1 radical hysterectomy with pelvic lymph node dissection or SLN mapping.
- Radical surgery for cervical cancer requires training, experience, and good ancillary support. This includes well-trained operating room personnel, surgical assistants, and anesthesia staff, as well as adequate radiology and intensive care. Consulting specialists should be a regular part of the management team.

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# CHAPTER 29

# SURGERY FOR OVARIAN CANCER

Ritu Salani and Mae Zakhour

**Ovarian Cancer**
Risk Factors for Developing Cancer
**Presentation**
Patterns of Spread
**Preoperative Evaluation**
**Surgery for Early Ovarian Cancer**
**Fertility-Sparing Surgery**
**Surgery for Advanced Cancer**
Primary Debulking Surgery
Exploration
Pafolacianine
Resection of Pelvic Tumor and Radical Oophorectomy
Lymphadenectomy
Small Bowel and Ileocecal Resection
Appendectomy and Cancer Debulking
Resection of Rectosigmoid Colon
Resection of the Urinary Tract
Omentectomy

Resection of Diaphragm Tumor

Splenectomy

Liver Resection and Biopsy

Placement of Intraperitoneal Port

**Minimally Invasive Surgery in Ovarian Cancer**

Laparoscopic Scoring and Assessment

**Neoadjuvant Chemotherapy and Interval Cytoreductive Surgery**

**Hyperthermic Intraperitoneal Chemotherapy**

**Surgery for Recurrent Disease**

**Palliative Surgery for Recurrent Disease**

Management of Bowel Obstruction

Gastrostomy Tube Placement

**Surgery for Other Ovarian Neoplasms**

Germ-Cell Tumors

Sex Cord-Stromal Cell Tumors

**Low Malignant Potential Tumors**

**Ovarian Cancer Diagnosed in Pregnancy**

Ovarian cancer is the leading cause of death from gynecologic malignancies in the United States. In 2021, the American Cancer Society estimates that ~21 410 new cases of ovarian cancer will be detected in the United States and nearly 13 770 women will die from the disease. Approximately 90% of malignant ovarian tumors are of epithelial origin, and this will be the focus of this chapter. The remaining tumors include sex cord-stromal tumors (6%), germ-cell tumors (3%), and metastatic or miscellaneous tumors. **TABLE 29.1** lists the classifications of malignant ovarian cancers. The average age of diagnosis of epithelial ovarian cancer is 63 years. In the

general risk population, epithelial ovarian cancer is rarely diagnosed before age of 40, and the lifetime risk for ovarian cancer in American women without a family history of the disease is 1 in 70 (1.4%). Because early ovarian cancer produces few specific symptoms, most women present with advanced-stage disease for which the cost of treatment is high and the prognosis is poor.

## TABLE 29.1
## World Health Organization Histological Classification of Malignant Ovarian Tumors

| |
|---|
| **Surface Epithelial Tumors (Invasive or Borderline)** |
| Serous |
| Mucinous |
| Endometrioid |
| Clear cell |
| Transitional cell (Brenner or non-Brenner type) |
| **Epithelial-Stromal Tumors** |
| Adenosarcoma |
| Carcinosarcoma |
| **Sex Cord-Stromal Tumors** |
| Granulosa cell |
| Sertoli cell |
| Leydig cell |
| Sex cord tumor with annular tubules |
| Gynandroblastoma |
| Steroid (lipid) cell tumors |
| **Germ-Cell Tumors** |
| Teratoma (mature and immature) |
| Monodermal variants (eg, struma ovarii, carcinoid) |
| Dysgerminoma |
| Endodermal sinus (yolk sac tumor) |
| Mixed germ-cell tumors |
| **Metastatic** |
| Colonic (colorectal/appendiceal) |
| Breast |
| Gastric |

Surgical management of ovarian cancer is a blend of good judgment and sound surgical technique. This chapter will be devoted to the surgical approaches and procedures for ovarian cancer. The background information provides the surgeon with the basis for

clinical decision-making concerning patient selection, choice of procedure, and postoperative treatment recommendations.

# OVARIAN CANCER

## Risk Factors for Developing Cancer

There are several theories regarding the pathogenesis of ovarian cancer (**TABLE 29.2**). The most commonly accepted theory is that of incessant ovulation, where the surface epithelium is routinely ruptured and then undergoes rapid proliferation and repair and places the ovary at risk for neoplastic transformation that may occur under the influence of oncogenic factors. Risk factors for developing ovarian cancer include nulliparity, early menarche, and late menopause. A second theory is that retrograde menstruation results in transportation of carcinogens from the uterus and lower genital tract to the fallopian tube and onto the ovary. This includes transport of cells from endometriosis, which has been associated with specific subtypes of epithelial ovarian cancer, specifically clear cell, endometrioid, and low-grade serous cancer. This theory is further supported by the observation that tubal ligation and hysterectomy are associated with decreased risk of ovarian cancer. Other theories propose that exposure of ovarian epithelium to persistently high levels of pituitary gonadotropins results in neoplastic transformation, as seen in patients with infertility and polycystic ovarian syndrome. Lastly, environmental exposures such as obesity and cigarette smoking (associated with mucinous tumors) are associated with increased risk of cancer.

### TABLE 29.2
### Factors Associated With Ovarian Cancer

| RISK FACTORS | PROTECTIVE FACTORS |
|---|---|
| Nulliparity | Oral contraceptive use |
| Early menarche | Tubal ligation |
| Late menopause | Hysterectomy |
| Family history | Breastfeeding |
| Infertility | |
| Endometriosis | |
| Genetic predisposition | |
| BRCA1 | |
| BRCA2 | |
| Lynch syndrome (*MSH2*, *MLH1*, *PMS2*, *MSH6*) | |
| *RAD51C* and *RAD51D* | |
| *BRIP1* | |
| *PALB2* | |
| *BARD1* | |

Another well-established explanation for the development of ovarian cancer is the contribution of family history and genetic predisposition. In women with a first-degree relative with ovarian cancer, the risk of ovarian cancer increases to 5%; however, only 5%-10% of ovarian cancer patients report a family history of the disease. Approximately 15%-20% of ovarian cancer cases are associated with a germ-line mutation. The lifetime risk of ovarian cancer is significantly increased and approaches 40% for patients with a *BRCA1* mutation, 20% with a *BRCA2* mutation, and 3%-14% in patients with Lynch syndrome.

Mutations in *BRIP1*, *RAD51C/D*, *PALB2*, and *BARD1* are also associated with hereditary ovarian cancer. All women with epithelial ovarian cancer are advised to undergo genetic testing.

# PRESENTATION

Ovarian cancer is associated with vague symptoms and does not lend itself to early diagnosis. The most common symptoms of patients with early-stage ovarian cancer are abdominal bloating, pain, indigestion, urinary frequency, and constipation. Because many symptoms are nonspecific, patients are unaware of their association with ovarian cancer. As a result, 22% of patients ignore their symptoms entirely and 30% report that the wrong diagnosis was made. This explains why over 75% of ovarian cancers are diagnosed at advanced stage. It is imperative that patients and physician understand the relationship of nonspecific abdominal symptoms and the possibility of diagnosing ovarian cancer. A high index of suspicion, coupled with the appropriate evaluation, may lead to an earlier diagnosis of ovarian cancer.

When an adnexal mass is noted and suspicious for malignancy, referral to a gynecologic oncologist is advised to determine the best management and plan surgical intervention. Unfortunately, many women with ovarian cancer are not seen by specialists and receive substandard care, resulting in inferior survival outcomes. Therefore, it is important to recognize clinical scenarios that suggest an ovarian malignancy and plan referral to a specialist.

## Patterns of Spread

Ovarian cancer spreads by (1) direct extension and exfoliation of tumor cells into the peritoneal cavity, (2) lymphatic metastases to regional and para-aortic lymph nodes, and (3) hematogenous dissemination. The specific pattern of spread depends on the stage, cell type, and histologic differentiation of the tumor. The earliest method of spread in epithelial ovarian cancer is by exfoliation of tumor cells from the ovarian surface. These cells follow the circulation of peritoneal fluid along the surfaces of the pelvic and

mesenteric peritoneum. They are also carried cephalad in the paracolic spaces to the omentum and undersurface of the diaphragm. Spread to the right lung occurs through the transdiaphragmatic lymphatics in the right hemidiaphragm, often producing a right pleural effusion. Surface spread to the peritoneal surfaces of the bowel and bladder is a common finding in advanced-stage ovarian cancer, but involvement of the bowel lumen or bladder mucosa is rare. The diaphragm is a common site of disease (**FIGS. 29.1 and 29.2**).

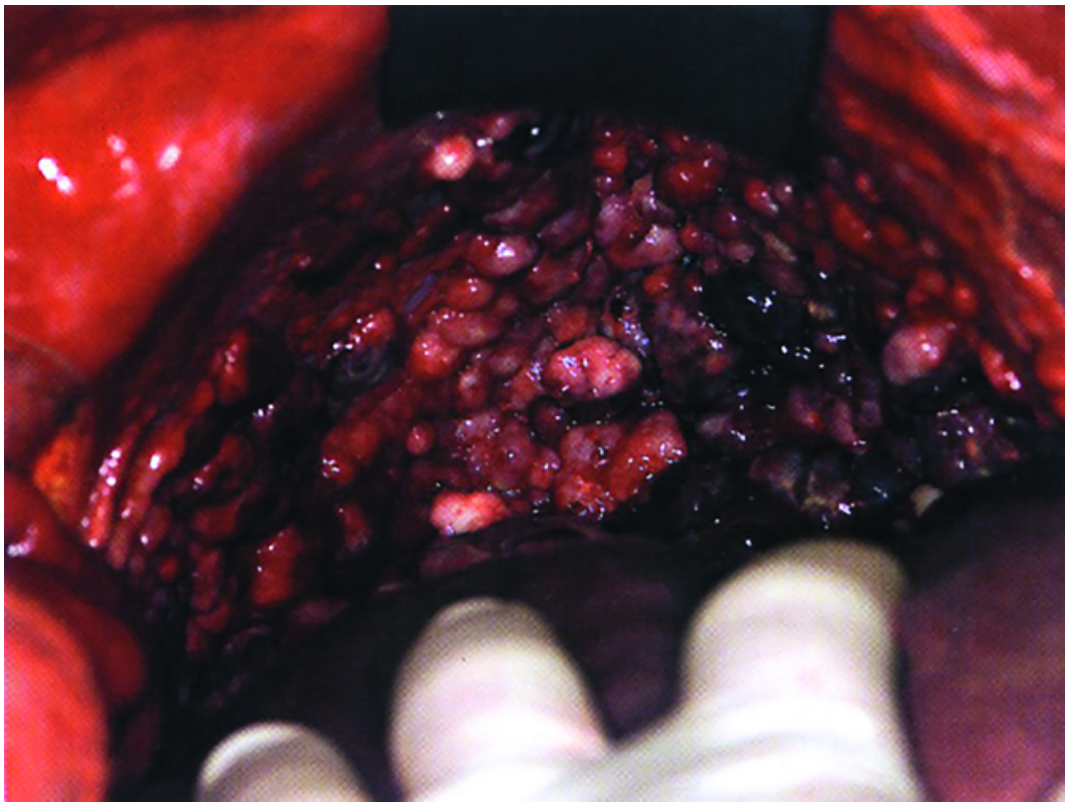


**FIGURE 29.1** Ovarian cancer disseminated to the diaphragm.

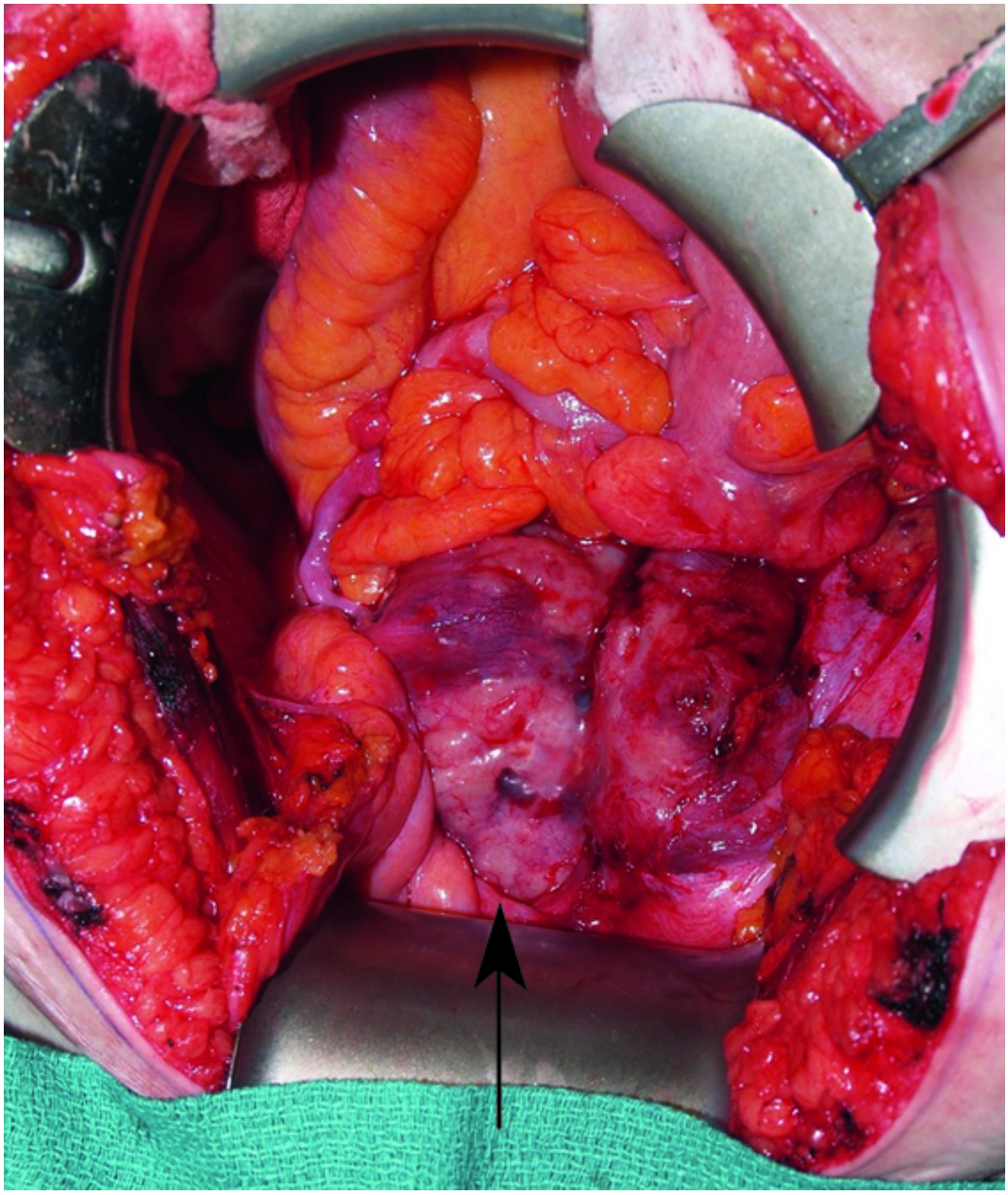


**FIGURE 29.2** Disseminated cancer with tumor implants on the sigmoid colon, sigmoid mesentery, pelvic sidewall, ovary, utero-ovarian ligament, and bladder peritoneum.

Lymphatic drainage from the ovary follows two pathways. The first involves lateral spread through the broad ligament to the pelvic

lymph nodes. In patients with advanced-stage disease, retrograde dissemination may also occur via the round ligament lymphatics to the inguinal lymph nodes. The second pathway of efferent lymphatic drainage follows the ovarian vein to the paracaval and para-aortic lymph nodes. Metastatic spread of ovarian cancer to lymph nodes is well documented even in early-stage disease and confirms that there may be separate pathways of dissemination to the pelvic and para-aortic lymph nodes. Even in early-stage disease (confined to the ovary), lymph node metastases are reported in up to 15% of cases, including involvement of the contralateral lymph nodes. The incidence of lymph node metastases increased from 20% in well-differentiated ovarian cancers to 65% in poorly differentiated tumors and is higher in serous ovarian malignancies than in mucinous or endometrioid cancers. Hematogenous spread of ovarian cancer to liver parenchyma or lung is rare (<5%).

# PREOPERATIVE EVALUATION

Before proceeding to surgery, each patient should undergo a thorough evaluation to determine the anatomic location, size, and morphology of the ovarian tumor, as well as possible metastatic sites for surgical planning. In addition, a patient's medical condition and the ability to undergo a major surgical procedure should be evaluated.

A computed tomography (CT) scan of the abdomen and pelvis can provide valuable information concerning retroperitoneal lymphadenopathy, omental disease, and peritoneal metastases. If advanced disease is suspected, a CT scan of the chest should be performed to assess for pleural effusion or the presence of pulmonary metastases.

The ovary is also a common site of metastases from nongynecologic cancers including gastrointestinal malignancies (colon, stomach) and breast cancer. A careful history and physical examination may arouse suspicion that patient symptoms and physical findings are due to a nongynecologic malignancy. If another primary site is suspected, diagnostic evaluation with colonoscopy,

upper endoscopy, or mammogram should be performed. A core biopsy or paracentesis can be performed to confirm the diagnosis.

Serum tumor markers should be assessed to provide a baseline value. CA-125 levels are elevated in patients with epithelial ovarian cancer, particularly in those with serous cancers. CEA and CA-19-9 levels may be elevated in some ovarian cancer cases or may suggest the presence of a colorectal cancer or pancreatic cancer; if these are significantly elevated, evaluation for these cancers should be considered. Elevated serum alpha-fetoprotein, human chorionic gonadotropin, or lactate dehydrogenase levels are increased in younger women with germ-cell ovarian malignancies and are not associated with epithelial cancers. Serum inhibin is the most reliable marker in patients with granulosa cell tumors of the ovary. The specific marker associated with each type of ovarian cancer is listed in **TABLE 29.3**.

## TABLE 29.3
## Serum Markers in Ovarian Cancer

| TUMOR HISTOLOGY | SERUM MARKER |
|---|---|
| Epithelial ovarian cancer | CA-125 |
| Mucinous cystadenocarcinoma | CA-19-9, CEA |
| Endodermal sinus tumor | AFP |
| Embryonal cell carcinoma | hCG, AFP |
| Choriocarcinoma | hCG |
| Dysgerminoma | LDH-1, LDH-2 |
| Granulosa cell tumor | Inhibin |

AFP, alpha-fetoprotein; CEA, carcinoembryonic antigen; hCG, human chorionic gonadotropin; LDH, lactate dehydrogenase.

Venous thromboembolism (VTE) is a common finding with malignancy occurring in 4%-20% of patients with a risk of death up to 9%. In the postoperative setting, development of VTE is associated with age (≥65), advanced malignancy, pelvic/abdominal surgery, increased body mass index, duration of surgery, and smoking. Due to the high incidence of VTE in ovarian cancer patients, pharmacologic VTE prophylaxis (+/− mechanical prophylaxis) is advised, and one option is to give a dose of low molecular weight heparin preoperatively before embarking on major surgery. Extended prophylaxis (28-35 days) using low molecular weight heparin or an oral factor Xa inhibitor reduces the risk of VTE and is not associated with increased risk of bleeding.

# SURGERY FOR EARLY OVARIAN CANCER

If an ovarian malignancy is suspected preoperatively, referral to a gynecologic oncologist for assessment is advised. If an ovarian cancer is diagnosed intraoperatively, ovarian cancer staging should be performed. An intraoperative consultation can be requested for gynecologic oncology assistance or other surgical oncologists to assist with lymphadenectomy and staging. If none is available, a survey of residual disease (omentum involved? peritoneal surfaces? other sites?) should be documented.

When an occult ovarian cancer is discovered on final pathology review following surgery performed for benign intent, the patient should be evaluated by a gynecologic oncologist for additional management. Despite the appearance of early-stage disease, occult metastases are common, occurring in up to one-third of cases. In a study by Morice et al., systematic bilateral pelvic and para-aortic lymphadenectomy detected lymph node metastases in 44% of cases. This upstaging has implications regarding prognosis and treatment.

Ovarian cancer is surgically staged according to the 2014 International Federation of Gynecology and Obstetrics (FIGO) staging system (**TABLE 29.4**). The goal of staging is to determine

the extent of metastatic disease. Because ovarian cancer frequently spreads to upper abdominal structures, a surgical incision needs to provide access to the pelvis and upper abdomen, stomach, omentum, liver, and undersurface of the diaphragm. Classically, this was performed with a vertical midline abdominal incision, which remains the choice for a laparotomy. Regardless of approach, rupture of a cystic ovarian malignancy is associated with a poorer prognosis, so the approach should be sufficient to allow for intact removal of the primary tumor. Serous tumors are bilateral in 50% of cases. The incidence of bilaterality for mucinous tumors varies widely in reported series, approximately 10-20%. Approximately 30%-50% of endometrioid and clear cell cancers are bilateral.

## TABLE 29.4
## FIGO Ovarian Cancer Staging (Updated January 1, 2014)

**Stage I: Limited to ovaries**

A. One ovary (capsule intact) or fallopian tube
B. Both ovaries (capsule intact)
C. Capsule ruptured
    1. Surgical spill
    2. Capsule ruptured before surgery or tumor on the surface of the ovary or tube
    3. Malignant cells in ascites or peritoneal washings

**Stage II: Pelvic extension below the pelvic brim or primary peritoneal carcinoma**

A. Uterus and fallopian tubes
B. Other pelvic tissues

**Stage III: Spread beyond the pelvis and/or involvement of lymph nodes**

A. Retroperitoneal nodes only and/or microscopic peritoneal metastases
    1. Retroperitoneal lymph nodes only
    2. Microscopic peritoneal metastasis
B. Macroscopic peritoneal metastasis ≤2 cm
C. Peritoneal metastasis >2 cm

**Stage IV (M1): Distant metastases**

A. Pleural effusion positive cytology
B. Parenchymal hepatic/splenic metastases or extra-abdominal organs (including lymph nodes)

**Other major recommendations are as follows:**

- Histologic type including grading should be designated at staging
- Primary site (ovary, fallopian tube, or peritoneum) should be designated where possible
- Tumors that may otherwise qualify for stage I but involved with dense adhesions justify upgrading to stage II if tumor cells are histologically proven to be present in the adhesions

Once abdominal access has been achieved, the following steps should be performed for adequate surgical staging (**TABLE 29.5**):

## TABLE 29.5
## Surgical Staging of Apparent Early-Stage Ovarian Cancer

| |
|---|
| Vertical midline incision |
| Evacuation of ascites or multiple cytologic washings |
| Complete abdominal inspection and palpation |
| Resection of ovaries, fallopian tubes, and uterus[a] |
| Omentectomy |
| Random peritoneal biopsies |
| Retroperitoneal lymph node sampling |

[a]Exceptions may be made in selected patients who wish to preserve fertility.

1. The volume of ascitic fluid should be recorded, and as much fluid as possible (minimum of 25 mL) should be sent for cytologic evaluation. This can be collected using a bulb syringe. Alternatively, if suction is used to aspirate ascites, the entire contents of the suction container can be sent to pathology.
2. In the absence of ascites, separate saline washings should be obtained by instilling 100 mL of saline into the peritoneal cavity, gently agitating the fluid, then collecting the contents using a bulb syringe, and sending the fluid to pathology. Fluid can also be collected using a suction apparatus connected to a collection trap.
3. The ovarian tumor should be inspected to determine the presence of papillary excrescences on the surface or rupture of the capsule. The contralateral ovary and uterus should be examined for the presence of metastatic tumor. The ovarian tumor should be removed and sent for frozen section examination. Even if benign appearing, the contralateral ovary is

usually removed except in cases of fertility-sparing surgery (see section on “Fertility-Sparing Surgery”).

4. The peritoneal surfaces, retroperitoneal structures (lymph nodes, kidneys), and intra-abdominal viscera are inspected and palpated. This evaluation should be approached in a systematic fashion. Starting at the ileocecal junction, the entire small bowel and mesentery should be evaluated (“run”) to the level of the ligament of Treitz. Inspection should continue with the ascending colon, liver, omentum, peritoneal surfaces of the right and left hemidiaphragms, and the stomach. Finally, the transverse colon, spleen, descending colon, and bladder peritoneum should be evaluated. It is important to document which of these sites contain metastatic disease and the size of the implants.
5. All suspicious areas, including adhesions, should be biopsied. In the absence of visible disease, staging includes collection of peritoneal biopsies from the anterior and posterior cul-de-sac, from bilateral pelvic sidewalls and bilateral paracolic gutters, and from right and left hemidiaphragms. These biopsies are performed by tenting the tissue away from underlying structures with a forceps or clamp and excising a sample of tissue either sharply or with electrocautery. The biopsy site should be inspected for hemostasis afterward.
6. An infracolic omentectomy should be performed in patients with epithelial ovarian cancer.
7. Appendectomy should be performed in all patients with mucinous epithelial cancers involving the ovary or if the appendix appears abnormal. Primary appendiceal cancers, although rare, commonly spread to the ovaries. If a primary appendiceal cancer is suspected, intraoperative consultation by a surgical oncologist should be requested with consideration of performing a hemicolectomy.
8. Patients with early-stage ovarian cancer may have para-aortic lymph node metastases in the absence of pelvic lymph node spread. Therefore, these lymph node groups should be sampled separately in all patients. It is important that sampling include

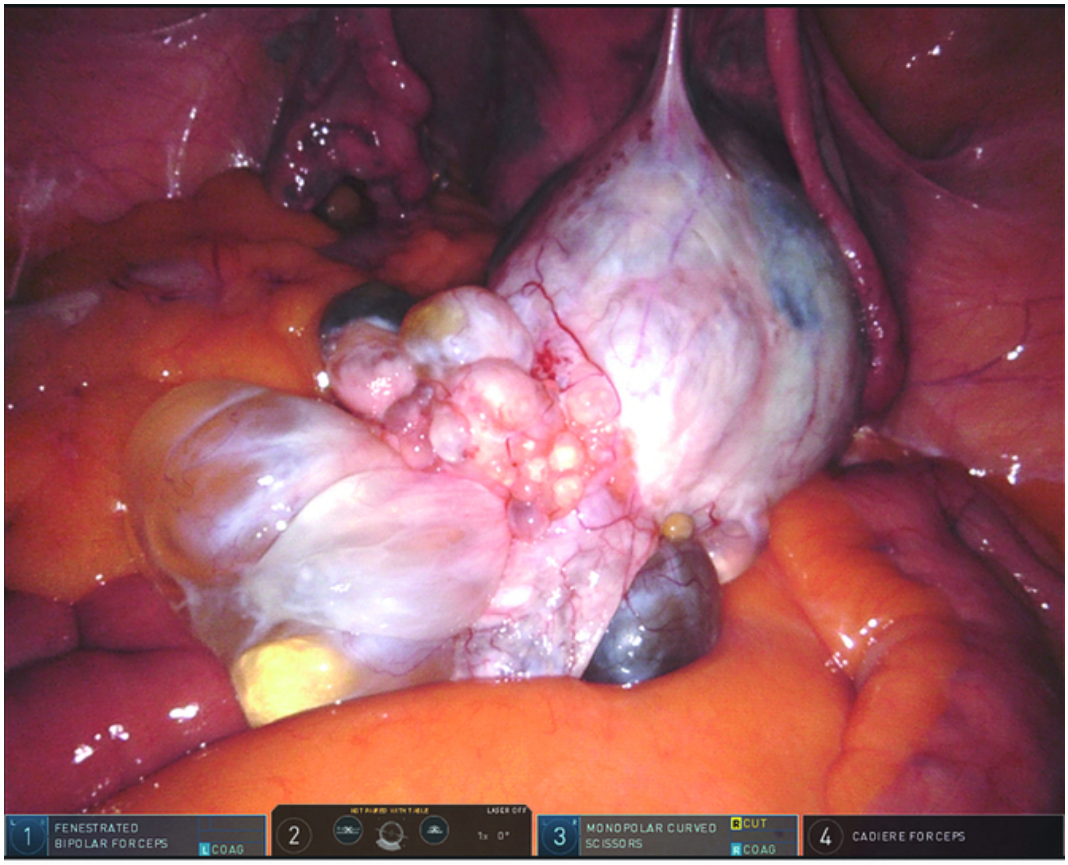
lymph nodes on the opposite side of the primary ovarian tumor because contralateral spread can occur (**BOX 29.1**).

## BOX 29.1 STEPS IN THE PROCEDURE

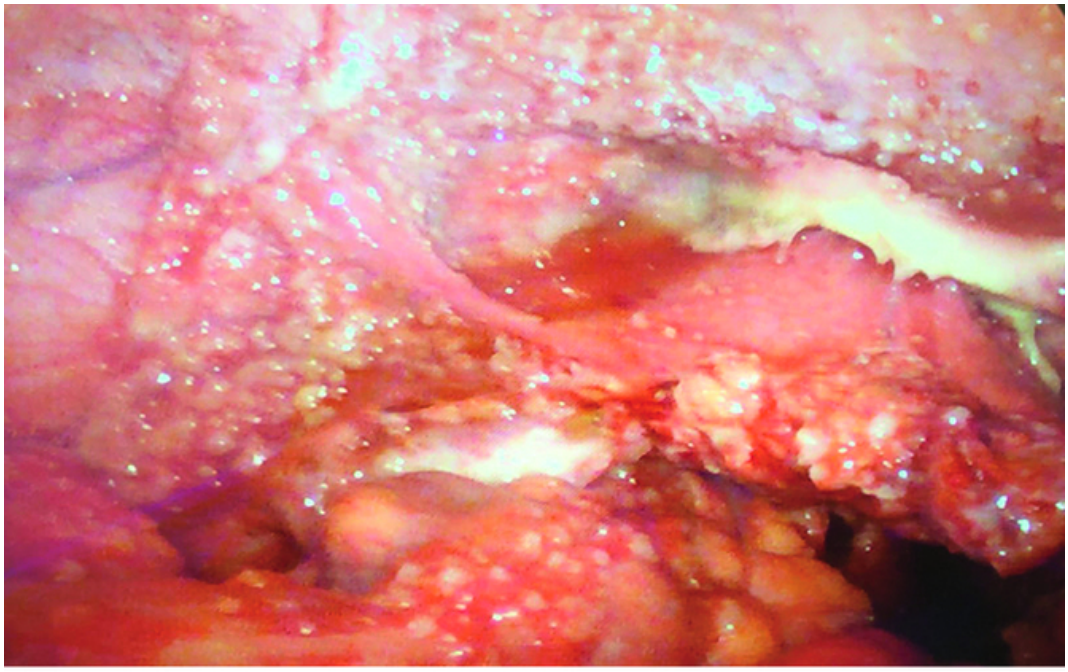
### Comprehensive Staging of Early Disease

- Entry into abdominal cavity and inspection of pelvic and peritoneal cavity.
- Washings obtained and sent for cytologic evaluation.
- Affected ovary isolated by identification of infundibulopelvic ligament.
- Ureter identified and isolated.
- Infundibulopelvic ligament cauterized and transected.
- Utero-ovarian ligament cauterized and transected.
- Ovary removed ensuring no spilling of ovarian tissue.
- Frozen section obtained and if consistent with cancer, then formal staging performed.
- Omentectomy (infracolic) is performed.
- Pelvic and para-aortic lymph node dissection performed bilaterally.
- Multiple peritoneal biopsies performed including both paracolic gutters, pelvic peritoneal surfaces bilaterally, and diaphragm peritoneum.

Operative findings present at the time of staging must be carefully documented. Prognosis is related to the site and volume of metastatic tumor, as well as the amount of residual disease remaining after surgical debulking. Important data concerning the location and size of tumor metastases are often lost if the details concerning operative staging are not recorded (**FIG. 29.3**).


1
FENESTRATED
BIPOLAR FORCEPS
L COAG
2
LASER OFF
3
MONOPOLAR CURVED
SCISSORS
R CUT
R COAG
4
CADIERE FORCEPS

A



B

**FIGURE 29.3** **A.** Early ovarian cancer with external excrescences. **B.** Diffuse carcinomatosis covering uterus, left ovary, peritoneal surfaces. (Courtesy of Dr. Linda Van Le, MD; University of North Carolina School of Medicine.)

## FERTILITY-SPARING SURGERY

Fertility-sparing surgery can be offered when early cancer is found in a young woman desiring preservation of fertility. Conservative management denotes surgery that preserves reproductive potential without compromising curability. With some exceptions, such a strategy may be applicable for women younger than 40 years who wish to bear children (**TABLE 29.6**).

### TABLE 29.6
### Criteria for Potential Fertility-Sparing Surgery in Ovarian Cancer Patients

| |
|---|
| Patient desirous of preserving fertility |
| Patient and family consent and agree to close follow-up |
| No evidence of dysgenetic gonads |
| Specific situations: |
| Any unilateral malignant germ-cell tumor |
| Any unilateral sex cord-stromal tumor |
| Any unilateral borderline tumor |
| Early-stage invasive epithelial tumor |

When contemplating surgery for a young patient with a high suspicion of an ovarian malignancy, it is important to preoperatively

discuss all possible operative findings, clinical scenarios, and surgical options. If the patient is a child, the parents need to clearly understand this information. Common errors in surgical management in this population include incomplete surgical staging and unnecessary bilateral salpingo-oophorectomy.

The optimal candidate for conservative surgical management is a young patient with stage I disease. If, on initial inspection, the ovarian mass is suspected to be malignant and confined to one ovary, unilateral salpingo-oophorectomy is appropriate. The specimen should be sent for frozen section examination. If malignancy is confirmed, the normal-appearing uterus and contralateral ovary can be preserved while all other elements of staging can be performed (biopsies, lymph node assessment, diaphragm assessment, omental biopsy, etc.). Random biopsy of a normal-appearing contralateral ovary is not recommended. Of note, one should not rely too heavily on frozen section examination in making the decision to perform a hysterectomy and bilateral salpingo-oophorectomy. If the histologic diagnosis is in question, it is always preferable to wait for permanent section results for a young patient, even if this requires a second surgery.

It has been the practice to perform hysterectomy if a bilateral salpingo-oophorectomy is performed. However, current technology for donor oocyte transfer and hormonal support allows a woman without ovaries to carry an intrauterine pregnancy. Similarly, if the uterus and one ovary are resected because of tumor involvement, fertility options still include retrieval of oocytes from the patient's remaining ovary, *in vitro* fertilization, and implantation of the embryo into a surrogate's uterus.

Several reports have detailed the reproductive outcomes of women with early-stage invasive epithelial ovarian cancer following treatment with fertility-sparing surgery with or without chemotherapy. A multi-institutional study in the United States evaluated the recurrence rate, survival, and pregnancy outcome in patients with stage IA and IC invasive epithelial ovarian cancers treated with unilateral adnexectomy +/− chemotherapy. Approximately 10% of patients recurred, and of the patients who attempted pregnancy, 71% conceived resulting in an 83% live birth rate. Long-term survival

and excellent obstetrical outcomes have been reported in patients with stage I epithelial ovarian cancer treated with fertility-sparing surgery.

# SURGERY FOR ADVANCED CANCER

## Primary Debulking Surgery

In the setting of advanced ovarian malignancy with diffuse extensive disease, the surgical goal pivots to debulking and excising as much tumor as possible. Surgery will confirm the diagnosis, determine the extent of the disease, provide palliation of symptoms, and impact prognosis with the resection of disease. As the extent of resection impacts prognosis, the terminology used to describe ovarian cancer surgical outcomes includes the following:

- Complete cytoreduction: Surgical resection to no grossly visible disease, also called R0 resection
- Optimal cytoreduction: Residual disease implants of ≤1 cm in maximum tumor diameter, called R1 resection
- Suboptimal cytoreduction: Cytoreduction with residual disease where each implant is >1 cm in tumor diameter

The role of surgery for ovarian cancer is well established with outcomes demonstrating an inverse relationship between residual tumor diameter and survival. In a meta-analysis of over 6000 patients with advanced-stage ovarian cancer, Bristow and colleagues found that for every 10% increase in maximal cytoreduction, there was a 5.5% increase in median survival time. Ellater and colleagues performed a systematic review of 11 retrospective studies and found that optimal resection was associated with a significant improvement in overall survival when compared to suboptimal cytoreduction. These findings were reiterated in a recent meta-analysis, which reported that for every 10% increase in cytoreduction to no visible residual disease, an increase in survival of 2.3 months was observed. Regardless of disease dissemination, surgical cytoreduction can be achieved in

many cases when performed by a gynecologic oncologist, and the goal of primary debulking should be to achieve the smallest volume of residual disease even when debulking to no residual disease cannot be achieved. In the United States, up to 70% of cytoreductive surgery results in optimal resection and has been associated with acceptable morbidity. Operative mortality is reported to be <2% and complications include infection, hemorrhage, prolonged ileus, and cardiopulmonary problems. The incorporation of additional procedures may increase the rate of complications or present additional risks.

# Exploration

The patient is placed in the low lithotomy position with the legs in Allen stirrups (Allen Medical Systems, Cleveland, OH). This positioning allows the surgeon access to the vagina and rectum, allowing intraoperative bimanual examination, and access to the perineum if rectal resection and anastomosis is required. This also allows access for vaginal placement of an instrument such as a ring forceps or EEA sizer to guide the colpotomy should a retrograde hysterectomy be indicated.

The umbilicus should be examined as this can harbor metastatic disease, which should be excised. To assess the ability to optimally debulk a cancer, a minimally invasive procedure (discussed below) or minilaparotomy is undertaken to perform a thorough inspection of the abdominopelvic contents. In a typical patient with advanced disease, the omentum may be totally replaced by tumor, and the pelvis may be filled with tumor, making it difficult or impossible for the surgeon to distinguish normal pelvic structures. Findings that will also dissuade the surgeon from proceeding with aggressive tumor resection include extensive parenchymal hepatic involvement, diaphragmatic involvement with extension to the pleural cavity, extensive infiltration of the small intestinal mesentery, or bulky nodal disease above the renal vessels. If the tumor burden is felt to be unresectable, tumor biopsies or palliative procedures can be performed and the procedure can be terminated.

If a decision is made to proceed with debulking, a vertical midline incision is made to gain access to the entire peritoneal cavity (pubic symphysis to the level of the xiphoid). Upon entering the abdomen, the initial steps outlined under surgical staging are followed. After drainage of ascites, inspection and palpation is performed, and the size of the primary tumors(s) and extent of metastatic deposits are noted. If a diagnosis has not been established prior to surgery, a tissue sample, from a metastatic deposit (eg, omental or peritoneal nodule) or the ovarian mass, is sent for frozen section evaluation to confirm a diagnosis of primary ovarian cancer. In the interim, if planned, removal of the uterus, tubes, and ovaries can be performed. This allows for removal of the mass(es) and potential detection of subclinical metastases. The cervix is often removed but may be retained if there is a concern for peritoneal leakage of ascites or if removal will risk bladder injury. General principles of debulking are noted in **BOX 29.2**.

## BOX 29.2 STEPS IN THE PROCEDURE

### Primary Cytoreductive Surgery—Advanced Disease

- Midline abdominal incision is performed from the pubic symphysis to the xiphoid.
- Ascites is drained from all quadrants of the abdomen and pelvis.
- Supracolic omentectomy is performed extending from hepatic flexure to splenic flexure of the transverse colon.
- Resection of pelvic tumor including total hysterectomy and bilateral salpingo-oophorectomy and any grossly visible tumor.
- When pelvic tumor involves the distal large bowel, a rectosigmoid resection with anastomosis is performed.
- When disease is present in the small bowel, a resection of the involved segment of the small bowel is performed.

- Removal of enlarged lymph nodes is performed.
- Splenectomy is performed when there is evidence of capsular or parenchymal disease.
- Diaphragmatic stripping or resection is performed when the diaphragm is either superficially involved with tumor or when there is penetration of tumor through the diaphragm.
- Partial hepatectomy or distal pancreatectomy is performed when segments of the liver or distal pancreas are involved with tumor.

## Pafolacianine

In addition to imaging, the novel drug pafolacianine has been recently approved by the FDA to help with tumor detection at the time of surgical exploration. This agent uses a tumor-specific targeting molecule that binds to cancer cells. It is injected intravenously 2 hours prior to the surgery and results in luminescence of the cancer cells with the use of a fluorescent light. Pafolacianine was found to detect a cancerous lesion in ~27% of cases that were not identified by visual or tactile evaluation. This approach is still undergoing evaluation and further role of its application is to be determined.

# Resection of Pelvic Tumor and Radical Oophorectomy

After entry into the peritoneal cavity and inspection, adhesions of the small intestine or cecum to the pelvic structures should be lysed. When access is adequate, a self-retaining retractor is placed and the bowel packed for adequate exposure. If the pelvic mass is not adherent to the surrounding structures, a hysterectomy and bilateral salpingo-oophorectomy can be performed. However, if normal pelvic spaces and planes are obliterated by tumor, then the retroperitoneal approach, also known as a radical oophorectomy, may be preferred.

The technique of the radical oophorectomy is defined by the intact removal of a fixed ovarian tumor *en bloc* with the attached peritoneum and surrounding pelvic structures in the setting of a "frozen" or fixed pelvis. Typically, this involves an *en bloc* resection including a retroperitoneal radical hysterectomy, excision of the adnexa, cul-de-sac tumor, involved peritoneum, and a rectosigmoid resection. This procedure is indicated for women with tumor burden extensively involving the surrounding pelvic structures and in whom a complete cytoreduction is feasible. Radical oophorectomy is further classified based on radicality of the procedure.

- Type I: A radical modified retrograde hysterectomy, with en bloc resection of the adnexa, cul-de-sac tumor, and involved pelvic peritoneum. This may include excision of the peritoneum or serosa of the anterior rectosigmoid colon or a full-thickness wedge resection of the anterior wall of the sigmoid colon.
- Type II: In addition to the structures removed in a type I procedure, the rectosigmoid colon below the peritoneal reflection is resected, as well as a parietal and visceral pelvic peritonectomy.
- Type III: The most radical of the procedures, a type III radical oophorectomy includes a type I or II procedure, as well as resection of a portion of the bladder and/or pelvic ureter in the en bloc resection.

This procedure requires access to the retroperitoneum, which can be entered after dividing the round ligaments or from the paracolic gutters and mobilization of the cecum, terminal ileum, and sigmoid colon. The paravesical and pararectal spaces are entered. The peritoneal incision is carried along the posterior margin of the pubic symphysis, effectively encompassing the pelvic disease within limits of the peritoneal incision. The ureters are identified and mobilized and can be tagged with vessel loops to allow for quick identification and to apply gentle traction on the ureters when needed for dissection. The infundibulopelvic ligaments are isolated and divided proximally above the pelvic brim, and the uterine arteries are divided at their origin. The peritoneal incision is extended anteriorly over the bladder, and the bladder is dissected away from the lower uterine segment and cervix. If the bladder peritoneum is extensively involved with tumor, the space of Retzius can be opened and the bladder sharply dissected from the peritoneum. If the bladder is unavoidably entered, it can be dissected away from the affected peritoneum by using the mucosal interface as a guide to avoid additional cystotomies. Once the bladder peritoneum has been separated from the bladder, a ring forceps or EEA sizer can be placed vaginally to guide the colpotomy incision performed using an electrosurgical device (ESU). The hysterectomy is then performed in a retrograde fashion. The colpotomy can then be carried circumferentially with a vessel-sealing device or using a clamp, cut, and suture method. The posterior vagina is then transected and the rectovaginal space entered and developed. If the posterior cul-de-sac is obliterated by tumor, healthy unaffected rectum can be identified below the peritoneal reflection, as ovarian cancer usually respects the borders of the peritoneum and rarely involves the retroperitoneal spaces. The rectovaginal space is developed caudally until the inferior margin of the cul-de-sac disease is bypassed by at least 2 cm. The specimen is pulled upward, and within the rectovaginal space, the remaining cardinal ligaments, uterosacral ligaments, and rectal pillars are isolated, divided, and suture ligated. The cul-de-sac tumor is sharply dissected from the anterior rectal wall and moving cephalad toward the rectosigmoid junction, conserving as much of the rectum as

possible for future anastomosis. See Chapter 1 for diagram of pelvic spaces used for dissection for this procedure.

The radical oophorectomy is then completed with a type I or type II modification, depending on the involvement of the rectum and sigmoid colon. In the type I modification, the cul-de-sac disease has limited or no involvement of the rectum and sigmoid colon. This allows the posterior broad ligament peritoneum to be entirely resected en bloc with the specimen by extending the bilateral peritoneal incisions created from the transection of the infundibulopelvic ligaments along the lateral pelvic gutters to the cul-de-sac. If there is no extension of tumor to the rectum, the peritoneal incision can be sharply carried over the anterior surface of the rectosigmoid colon, and no colonic resection is needed. If there is limited muscularis involvement (<2 cm extent), then a wedge resection of the anterior rectal wall can be performed. The resulting rectal defect can be closed with a hand-sewn technique of interrupted inverting stitches placed perpendicular to the long axis of the bowel or reapproximated using bowel staplers.

When a “frozen pelvis,” tumor that obliterates a normal pelvic anatomy including dense involvement of the rectosigmoid colon, is present, a type II modification is necessary. This is further classified based on location of distal margin of the colon resection to the anal verge. A low rectal resection is performed within 7 cm of the anal verge, a middle resection is 7-11 cm away, and a high resection is >11 cm from the anal verge. Ideally, the maximal amount of unaffected colon is conserved. If a rectosigmoid colectomy is required, a 2-cm proximal margin should be obtained. This can be performed with a gastrointestinal anastomosis (GIA) stapler.

After including an adequate resection of mesocolon, the deep dissection continues from the pararectal spaces medially, behind the sigmoid vessels, and the superior hemorrhoidal artery toward the presacral space. This joins the pararectal and presacral spaces. The dissection continues, anterior to the presacral fascia, and the lateral ligaments of the rectum are taken down using a vessel-sealing cutting device. The cul-de-sac mass is lifted, and the unaffected rectum distal to the infiltrating tumor is isolated and cleared of any surrounding fat or attachments. The rectum is then divided at least 2

cm distal to the lowest site of disease using a thoracoabdominal (TA) stapler and bowel clamp proximally. The central pelvic tumor is then removed en bloc with the rectosigmoid colon resection. A supracervical hysterectomy may be advisable if obliterative disease or fibrosis is present. The bowel can be reanastomosed by a variety of methods, including use of a stapler device or a hand-sewn technique. See Chapter 38 for discussion of gastrointestinal procedures.

Though not often indicated, the type III radical oophorectomy is performed when removal of a portion of the urinary tract is required as part of cytoreductive procedure. If the bladder is involved, after identification of the ureteral orifices (stents placed if needed), the affected portion of the bladder may be resected. The cystectomy can be repaired in two layers with an imbricating closure using a delayed absorbable 2-0 or 3-0 delayed absorbable suture in a running fashion. A transurethral bladder catheter is placed for 7-10 days postoperatively. A CT cystogram can be ordered to assess if there is leakage from the cystectomy repair and may impact the timing of catheter removal. In the case that the pelvic ureter is either involved with direct invasion of tumor or is encased or densely adherent to tumor, a partial ureterectomy is indicated. The ureter is mobilized from the peritoneum to the level of the obstruction, and the segment of ureter to be excised is suture ligated proximal and distal to the obstruction. The radical oophorectomy is completed prior to repair of the urinary tract. Reconstruction of the resulting defect is determined by the location of the excision, and the length and condition of the residual ureter. As these anastomoses are not watertight, stent placement and drainage of the pelvis with a closed suction device is recommended. If high output is present, a sample of pelvic fluid can be sent to measure creatinine to determine if urine is leaking into the pelvis.

# Lymphadenectomy

The initial retroperitoneal approach for cytoreductive surgery exposes the node-bearing areas. For early-stage cancer lymph nodes, sampling is a mandatory component of surgical. For women

with clearly metastatic disease, every effort should be made to remove suspicious or bulky lymph nodes. While lymph node metastasis is present in 60% of advanced ovarian cancer, the phase III LION trial did not demonstrate a clinical benefit to performing lymphadenectomy when advanced disease is present. Furthermore, lymphadenectomy is associated with increased perioperative morbidity, such as significantly longer operative times, higher blood loss, higher transfusion rates, higher readmission rates, and increased risk of death within 60 days from surgery. Therefore, the omission of lymphadenectomy in the absence of abnormality in patients with advanced ovarian cancer is acceptable.

The rate of lymph node involvement is uncommon in mucinous tumors and may be omitted. Additionally, metastatic disease to lymph nodes in sex cord-stromal tumors is uncommon and can also be omitted. The significance of lymph node dissection in malignant germ-cell tumors, especially dysgerminoma, is controversial, and ongoing studies in pediatric oncology patients question the importance of lymphadenectomy for these tumors. Steps for performing lymphadenectomy are described in Chapter 27 (**VIDEO 29.1**).

# Small Bowel and Ileocecal Resection

The small intestine serosa and mesentery are common sites of metastasis. If loops of small intestine are adherent to the pelvic tumor, omental tumor, or other loops of intestine, then these adhesions should be lysed. Indications for small intestine resection include obstruction or impending obstruction by tumor infiltrating the serosa and muscularis of a segment or a nonobstructing extensive lesion of the small intestine for which resection would result in minimal residual disease.

If the small intestine is extensively involved with tumor, it is usually the terminal ileum. In this situation, an ileocecectomy with resection of the terminal ileum, cecum, and a portion of the ascending colon may be necessary. The procedure commences with incising the peritoneum along the line of Toldt from the terminal ileum, around the cecum, and up to the hepatic flexure to mobilize

the ascending and hepatic flexure. The peritoneal incision is carried around the hepatic flexure through the hepatocystocolic ligament. This creates improved mobility of the ascending colon and hepatic flexure to allow for resection of the diseased colon and a tension-free anastomosis for repair. The ileum is mobilized by making a peritoneal incision along the small bowel mesentery and carrying it toward the ligament of Treitz. The mobilized structures are reflected medially in order to identify the underlying structures, including the right ureter, gonadal vessels, duodenum, and the head of the pancreas. At this point, the extent of the resection can be determined. It is recommended that the distal 8-10 cm of the terminal ileum be included in the resection to allow for an anastomosis in a well-vascularized segment of the ileum. A wedge of the ileocecal mesentery is included in the resection. The amount of ascending colon to be excised is determined by the amount of disease present. Preservation of the right colic artery is recommended if only the cecum is involved; however, if a more extensive resection of the ascending colon is indicated, preservation of the middle colic artery is recommended. The specimen is removed en bloc once the mesenteric vessels are divided. The reanastomosis may be performed using a suture or stapling technique. A side-to-side functional end-to-end ileoascending colon anastomosis allows for a widely patent and reliable method for reestablishing intestinal continuity. See Chapter 38 for details of small bowel resection.

## Appendectomy and Cancer Debulking

Removal of the appendix may be indicated during surgery for certain ovarian cancers such as mucinous ovarian tumors or when pseudomyxoma peritonei, which can accompany an occult appendiceal primary, is present. If a primary appendiceal cancer is diagnosed, an ileocectomy is indicated and consideration should be given to asking for intraoperative general surgery or surgical oncology consult. An appendectomy may also be indicated if the appendix is involved with metastatic ovarian cancer. See Chapter 38 regarding steps for performing appendectomy.

# Resection of Rectosigmoid Colon

Disease is often present on the rectosigmoid colon in advanced ovarian cancer. Small, superficial nodules are amenable to simple resection without disrupting the integrity of the bowel wall. However, larger-volume disease may require a rectosigmoid resection and reanastomosis. This is performed in 10% of patients undergoing primary debulking. The decision to perform a resection depends on several factors, including the presence or absence of rectosigmoid obstruction, the amount of tumor infiltration of the lower colon and its contiguity with the ovarian cancer, and the probability that such a procedure will benefit the patient and render her “optimally debulked.” If a rectosigmoid colon resection is performed, in most cases, the colon can be reanastomosed using either a suture technique or the end-to-end anastomosis (EEA) stapler. For patients who undergo a reanastomosis, a transverse loop colostomy or loop ileostomy protects the anastomosis for those who have received pelvic radiotherapy, have unprepared colon, or when anastomosis is judged to be suboptimal and at risk of leak. Occasionally, an end colostomy with a Hartmann pouch is performed. Potential complications of rectosigmoid resection and anastomosis include pelvic abscess, strictures, anastomotic leaks, and surgical site infections.

Occasionally, a patient will limit the surgeon’s intraoperative decision-making ability by refusing to consent to possible colostomy. In our experience, resection of the rectosigmoid colon can be accomplished with minimal residual disease in the pelvis. However, there may be unresectable bulky residual tumor in the upper abdomen or retroperitoneum. In such cases, palliative resection in the absence of obstruction is not recommended. If optimal resectability is unable to be performed and an obstruction is present, diversion of the bowel with a loop colostomy, or less commonly an intestinal bypass procedure, may be required. A rectal stent may also be placed for palliation.

# Resection of the Urinary Tract

Ureteral resection or partial cystectomy are not often performed as part of cytoreductive surgery. If ureteral obstruction is noted preoperatively, it is almost always a result of ureteral compression rather than tumor infiltration. Although adherence of the ureter to masses of ovarian cancer is not an unusual finding, the surgeon can almost always separate the ureter from the tumor using sharp dissection. If the distal ureter is resected as part of cytoreductive surgery, it can be reimplanted into the bladder. More commonly, the ureter may be injured during the course of debulking surgery. Depending on the site and type of injury, ureteral stent placement, a primary reanastomosis, transureteroureterostomy, or ureteroneocystostomy may be indicated.

Tumor involvement of the peritoneum overlying the urinary bladder is common. Peritoneal stripping can be performed, and if a large area of the bladder has been exposed, short-term (1-2 days) decompression of the bladder with a catheter is planned. Occasionally, a partial cystectomy may be necessary to achieve optimal cytoreduction. If a partial cystotomy is indicated, we prefer a simple closure with two layers of absorbable suture, the inner layer as a continuous running suture and the outer layer as interrupted sutures. We recommend bladder decompression with a catheter. Timing of catheter removal is dependent on location and extent of resection. It is exceedingly rare to find involvement of the bladder mucosa with ovarian cancer at initial diagnosis. Such patients usually report hematuria in association with obvious massive disease, and definitive diagnosis can be made preoperatively by performing cystoscopy.

# Omentectomy

The omentum is comprised of four layers, as it is composed of a double sheet of peritoneum folded onto itself. It is divided into the lesser omentum and the greater omentum. The lesser omentum is composed of a double layer of the peritoneum that connects the liver to the lesser curvature of the stomach (the hepatogastric ligament)

and the first 2 cm of the duodenum (hepatoduodenal ligament). The greater omentum is also double layered and hangs off the greater curvature of the stomach and the transverse colon. An omentectomy is part of the surgical staging for early ovarian cancer and is usually a site of metastases in advanced disease. If the infracolic omentum is involved, it can be removed by first lifting the omentum cephalad and developing the plane between the infracolic omentum and the serosa of transverse colon, gaining entry to the lesser sac. The dissection is carried laterally in both directions, and the infracolic omentum is separated from the transverse colon from the hepatic flexure to the splenic flexure. The intervening vascular pedicles are sequentially clamped, cut, and suture ligated or may be controlled with a vessel-sealing cutting device.

It is our preference to perform an omentectomy before focusing on the pelvis if the omentum is largely or completely replaced by tumor (called an omental cake). Even when disease is not completely resectable, removal of the omental mass may decrease the production of ascites and improve patient symptoms. If the omental tumor is adherent to the parietal peritoneum of the anterior abdominal wall, the pelvic structures, or loops of the small intestine, it should be dissected from these structures. Once the omentum is mobilized and lifted cephalad, a dissection plane is developed between it and the serosa of the transverse colon, extending the dissection laterally in both directions (**FIG. 29.4A**). If the supracolic omentum is heavily involved with tumor and densely adherent to the transverse colon, it also may be necessary to establish a plane between the greater curvature of the stomach and the omentum by ligating the right and left gastroepiploic arteries and the individual gastric branches (**FIG. 29.4B**). Incising the dorsal reflection along the posterior border of the transverse colon will allow entry into the lesser sac. The lesser sac is then fully developed by mobilizing the omentum away from the transverse colon and transverse colon mesentery. The omentum is then divided from greater curvature of the stomach by creating pedicles and excision or using a vessel-sealing cutting device. If the tumor is in close proximity to the stomach, the gastroepiploic arcade may need to be sacrificed, a nasogastric tube should be placed to avoid gastric distension.

Occasionally, omental tumor may also involve the spleen or splenic hilum, necessitating a splenectomy. Care should be taken in performing omentectomy because if too much tension is placed on the omentum splenic avulsion can occur resulting in brisk hemorrhage and need for emergent splenectomy.

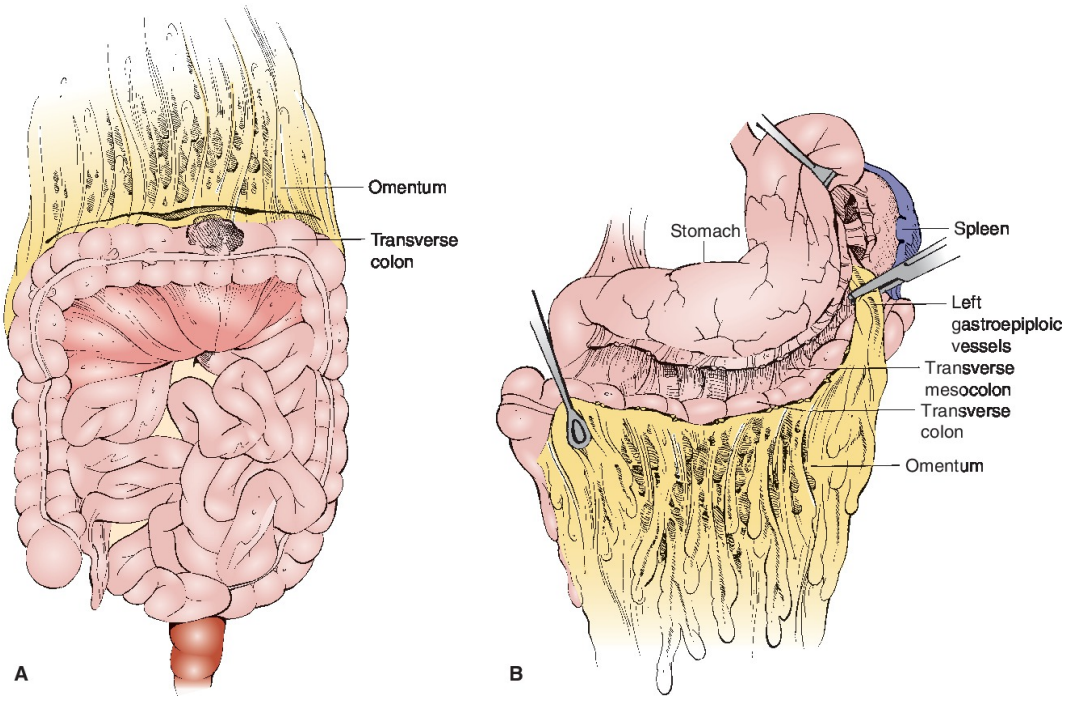



**FIGURE 29.4** **A.** Omentectomy. Avascular dissection plane between the omentum with metastatic ovarian tumor and transverse colon. **B.** Omentectomy. Dissection of the omentum with tumor from the stomach with ligation of gastric branches.

# Resection of Diaphragm Tumor

The diaphragm is the site of metastatic disease in 10%-15% of women with advanced-stage ovarian cancer. The right hemidiaphragm is more frequently and more extensively affected by disease due to its dependent location and due to the clockwise rotation of peritoneal fluid in the abdomen occurring as a result of colonic peristalsis and the draw of fluid into subdiaphragmatic spaces during inhalation. Resection of diaphragmatic disease resulted in an improved 5-year survival benefit. Diaphragm resection should be performed when it contributes to optimal/complete resection of metastatic ovarian cancer.

Access to the diaphragm peritoneum is facilitated by extending the midline incision to just below the xiphoid process. The extent and location of the disease on the diaphragm will determine the need for mobilization of the liver as well as the surgical approach, which are discussed below. If the liver requires mobilization, this can be achieved by first transecting the round ligament of the liver, followed by division of the falciform ligament toward its apex at the bifurcation into the coronary and triangular ligaments. The dissection must be superficial, as the hepatic veins empty into the vena cava just below the coronary ligament. “Spot” resection or ablation of small tumor nodules implanted on the peritoneal surface of the diaphragm disease can also be performed using sharp dissection, the argon beam coagulator, electrocautery, or a surgical aspirator.

When small-volume diaphragm disease is present that is not full thickness, diaphragm peritonectomy is performed. A peritoneal incision is made just above the diseased area. The peritoneum is raised and grasped with a series of clamps (eg, Allis clamps or ring forceps), and the peritoneum is stretched to allow for dissection away from the underlying diaphragm muscle. This can be performed sharply or with electrocautery continued until all diaphragmatic disease is removed.

Full-thickness peritonectomy is indicated when the tumor infiltrates through the peritoneum, into the muscle. Disease can also invade the pleural cavity. As this resection may affect ventilation, the anesthesia team should be notified. The involved area is isolated,

and the diaphragm muscle is transected with sharp dissection or electrocautery with a margin of 0.5-1 cm. Most defects in the diaphragm can be closed primarily using delayed absorbable suture in an interrupted or running and locking fashion. If a large defect cannot be closed primarily, a synthetic mesh can be used to close the defect. It is important to evacuate air to prevent development of pneumothorax occurring during the procedure. This can be managed by placing a 14-French red rubber catheter into the defect, with closing suture in place but untied. Several deep ventilatory breaths are administered and the catheter is placed on suction. The catheter is then rapidly removed and the opening in the defect is promptly closed. A chest x-ray should be obtained postoperatively to ensure expansion of the lung is not affected.

Complications related to diaphragmatic surgery include pneumothorax, pleural effusions, hemorrhage from the phrenic arteries or hepatic vessels, injury to the pericardial sac, lung, vena cava, and phrenic nerves. If a pneumothorax is noted, it may be managed expectantly or a chest tube can be placed.

# Splenectomy

Splenectomy is performed during primary debulking surgery for ovarian cancer in 4%-12% of cases (**FIG. 29.5**). Most commonly, the splenic hilum is involved with tumor secondary to extension from omental involvement. Splenectomy is indicated if a traction injury leading to significant bleeding from the splenic capsule occurs during omentectomy or mobilization of the splenic flexure.

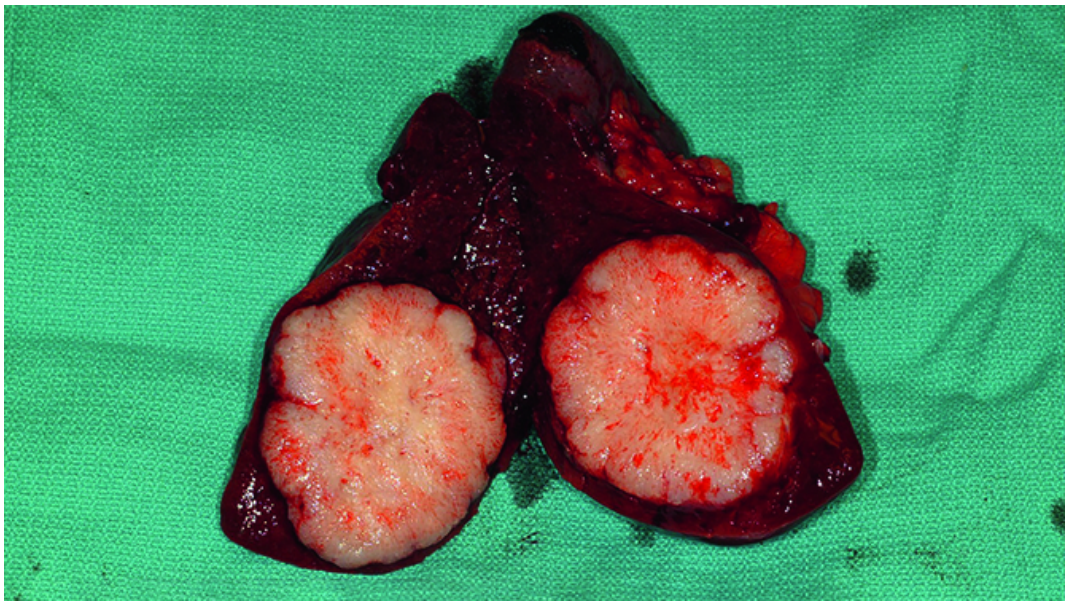


**FIGURE 29.5** Spleen with ovarian cancer metastasis.

The surgical approach to splenectomy is variable depending on the circumstances and indications of the procedure. The anterior approach is the most direct method to control the blood supply to the spleen. The spleen is accessed by ligating and dividing the left gastroepiploic vessels and the gastrosplenic ligament, allowing access to the lesser sac. The superior border of the body and tail of the pancreas and the splenic vessels are identified in this region. The vessels are individually isolated, ligated, and transected. To allow the blood to drain from the spleen, the artery should be ligated first (**FIG. 29.6**). The spleen is then mobilized by transecting its attachments to the colon (splenocolic ligament), the left kidney (lienorenal ligament), and the diaphragm.

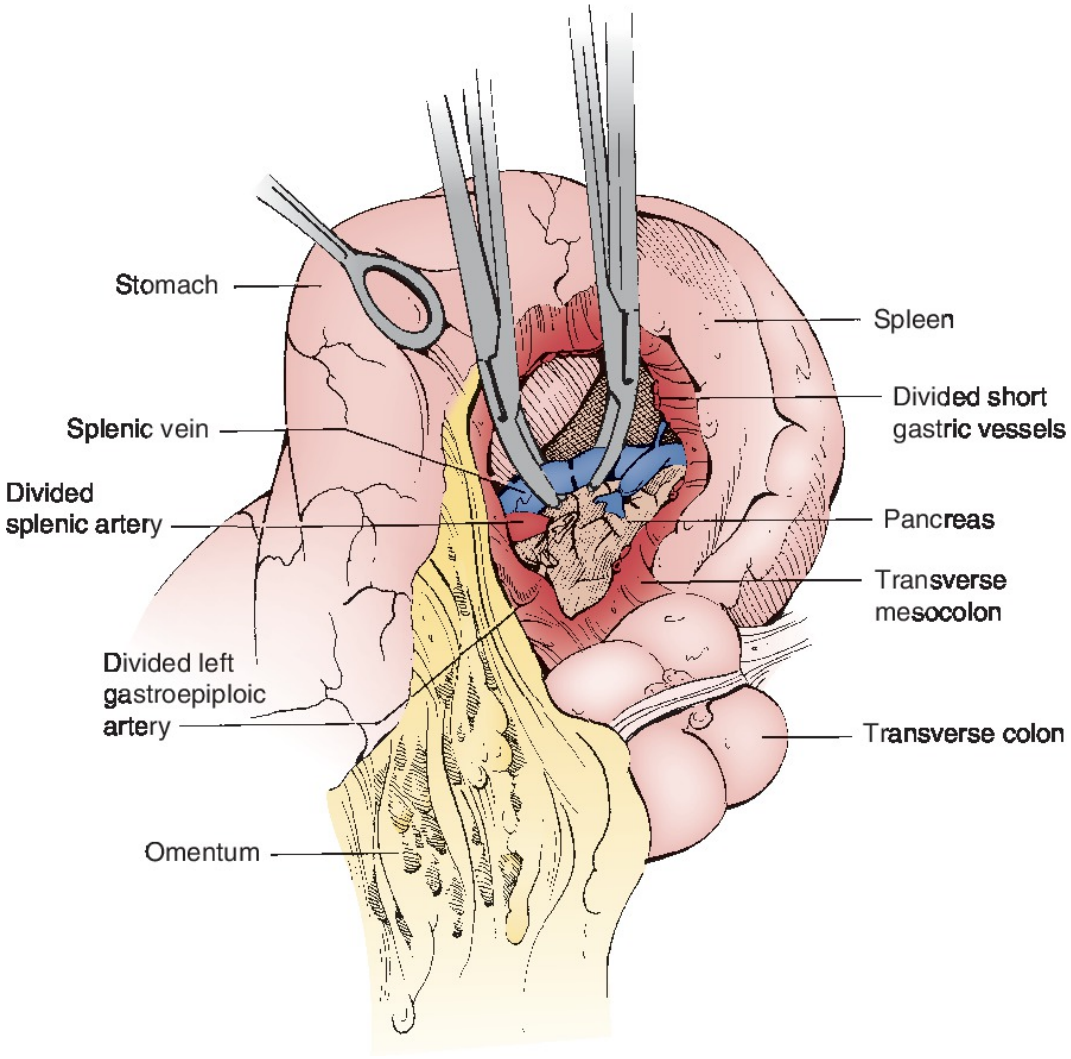



**FIGURE 29.6** Splenectomy. Transection of splenic artery and vein along the superior border of the pancreas after access is gained to lesser sac with transection of gastrosplenic ligament.

When access to the lesser sac is limited by tumor or bleeding, the posterior approach can be utilized. The lesser sac is approached through the lienorenal ligament rotating the spleen medially and anteriorly. After mobilization of the tail of the pancreas, the vessels are identified and isolated in a similar fashion as the anterior

approach. Lastly, the spleen is separated from the stomach, with care to avoid the gastric wall or blood supply.

Complications of splenectomy include hemorrhage, infection, thromboembolism, left-sided atelectasis, or pneumonia. Additional complications include injury to the tail of the pancreas resulting in pancreatic pseudocyst formation or injury to the stomach with possible formation of a gastric fistula. Due to risk of sepsis, patients undergoing a splenectomy should receive perioperative antibiotic coverage and should be vaccinated with the polyvalent pneumococcal, quadrivalent meningococcal, and *Haemophilus influenzae* vaccines. Vaccinations should be administered at least 14 days prior to a planned splenectomy or not until at least 14 days following splenectomy for patients in whom splenectomy was not anticipated.

# Liver Resection and Biopsy

Metastatic disease in the liver is usually an indication for neoadjuvant chemotherapy. However, in the setting of isolated or resectable liver metastases, partial hepatectomy may be considered to resect disease to obtain optimal/complete cytoreduction. This can be performed with electrocautery (electrosurgical unit or using a loop), argon beam ablation, or excision with stapling/ligation of bile ducts and vessels.

Occasionally, a liver biopsy may be required to confirm the presence or absence of cancer. This can be performed using a spring-loaded biopsy needle that is directly inserted into the lesion. After the biopsy, the needle is reinserted into the biopsy site and electrocautery is applied directly to the needle to achieve hemostasis. Potential complications include hemorrhage, coagulopathy, hyperglycemia, and bile leakage.

# Placement of Intraperitoneal Port

Intraperitoneal (IP) chemotherapy has been investigated as a primary treatment for patients with optimally reduced advanced epithelial ovarian cancer. Several randomized controlled clinical trials have demonstrated survival benefit of IP treatment over intravenous (IV) chemotherapy; however, recent studies have not shown a benefit to IP delivery of chemotherapy and IP chemotherapy is now less frequently offered.

Should IP treatment be chosen, peritoneal ports can be placed at the time of laparotomy during primary cytoreduction or delayed placement with a minilaparotomy, laparoscopic placement, or insertion via interventional radiologist. A 3- to 4-cm skin incision is made over the lower left or right costal margin in the midclavicular line. A small subcutaneous pocket is created for the port at the level of the abdominal fascia. A tunnel is then created just above the fascia of the pocket to the level of the umbilicus using a rod or a tonsil. At the level of the umbilicus, the rectus sheath, muscle, and peritoneum are entered with the tunneling device (this should be 5-6 cm lateral to the umbilicus). The catheter is connected to the device

intraperitoneally and pulled through the tunnel using the tunnel device up to the port site. The catheter is connected to the port, and the port is sutured to the fascia using a 2-0 monofilament nonabsorbable suture with three to four interrupted sutures circumferentially around the port for stabilization. The IP portion of the catheter is cut at a right angle leaving at least 12 cm within the peritoneal cavity. The port is then accessed only with a Huber needle (a hollow needle with a beveled tip used to access chemotherapy ports) and flushed with heparinized saline to check for patency and leaks. The subcutaneous Scarpa layer is closed over the port in a running fashion, followed by closure of the skin (**FIG. 29.7**).

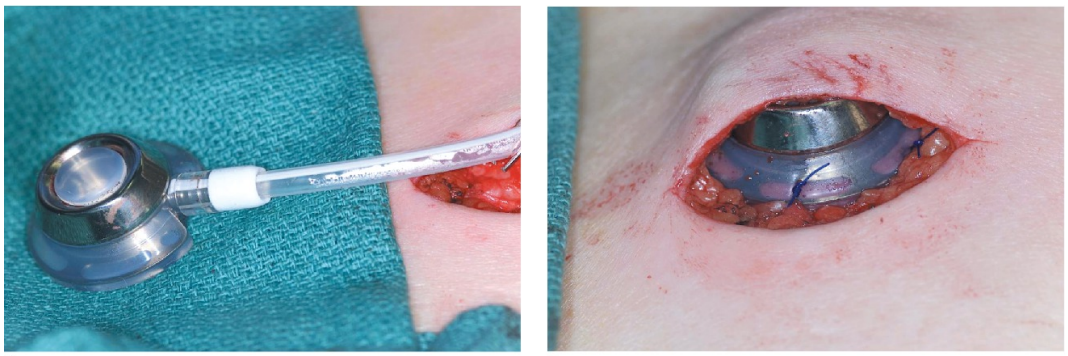



**FIGURE 29.7** **A.** Intraperitoneal (IP) port. **B.** Port is placed in subcutaneous pocket. (Reprinted with permission from De Vita VT, Lawrence TS, Rosenberg SA. *Cancer: Principles & Practice of Oncology*. 10th ed. Wolters Kluwer; 2015.)

# MINIMALLY INVASIVE SURGERY IN OVARIAN CANCER

A role for minimally invasive surgery (MIS), laparoscopic surgery, or robotic surgery, in the management of ovarian cancer, is evolving.

There are several clinical settings where this surgical platform has been investigated: (1) primary surgery for early-stage ovarian cancer, (2) restaging of unstaged ovarian cancer, (3) primary cytoreductive surgery for advanced-stage ovarian cancer, (4) assessment of resectability, (5) IP catheter placement, and (6) secondary cytoreductive surgery.

In a patient who has an adnexal mass with no other findings of metastatic disease, MIS may be the selected approach. If malignancy is noted intraoperatively, complete surgical staging via this approach is feasible and care should be taken to avoid rupture of the mass. Studies evaluating this approach have shown that the MIS approach is associated with improved postoperative outcomes and similar short-term outcomes when compared to laparotomy.

## Laparoscopic Scoring and Assessment

The role for diagnostic laparoscopy as a modality for assessing the feasibility of optimal surgical cytoreduction has evolved over the past decade. Several scoring tools have been proposed and published to date, of which the Fagotti predictive index has gained the most traction in clinical practice. The Fagotti scoring system assigns two points, for a range of 0-14, to each of the following when present at laparoscopy: omental caking, peritoneal carcinomatosis, diaphragm carcinomatosis, mesenteric retraction, stomach infiltration, bowel infiltration, and liver metastases. In the phase III randomized SCORPION trial optimal (R0) primary cytoreduction was achieved in only 47.6% of patients with a score ≥8 compared to 67% of patients treated with neoadjuvant chemotherapy prior to cytoreduction. Major postoperative complications were more frequent in the primary cytoreduction group, and there was no difference in progression-free or overall survival between the groups, indicating that neoadjuvant chemotherapy should be strongly considered in patients with advanced stage ovarian cancer and a high tumor burden, defined as a Fagotti score ≥8. Laparoscopic assessment should be considered for patients with advanced stage ovarian cancer in whom the

feasibility of achieving optimal cytoreduction is not clear from radiologic imaging studies (TABLE 29.7).

## TABLE 29.7
## Fagotti Scoring Algorithm

| TUMOR CHARACTERISTIC | SCORE |
|---|---|
| Peritoneal carcinomatosis:<br>Massive peritoneal involvement and/or miliary pattern of distribution | 0 (not present) or 2 (present) |
| Diaphragmatic surface involvement:<br>Widespread infiltrating carcinomatosis and/or confluent nodules to most of diaphragm surface | 0 (not present) or 2 (present) |
| Mesenteric involvement:<br>Large infiltrating nodules and/or involvement of the root of the mesentery based on limited movement of intestinal segments | 0 (not present) or 2 (present) |
| Omental involvement:<br>Tumor diffusion of the omentum up to the greater curvature of the stomach | 0 (not present) or 2 (present) |
| Bowel involvement:<br>Tumor infiltration of large or small bowel requiring intestinal resection (excludes rectosigmoid colon) and/or | 0 (not present) or 2 (present) |
| Stomach involvement:<br>Obvious tumor infiltration into gastric wall | 0 (not present) or 2 (present) |
| Liver involvement:<br>Liver surface lesions >2 cm in size | 0 (not present) or 2 (present) |

Reproduced with permission from Fleming ND, Nick AM, Coleman RL, et al. Laparoscopic surgical algorithm to triage the timing of tumor reductive surgery in advanced ovarian cancer. *Obstet Gynecol*. 2018;132:545-554. The authors provided this information as a supplement to their article. ©2018 American College of Obstetricians and Gynecologists.

# NEOADJUVANT CHEMOTHERAPY AND INTERVAL CYTOREDUCTIVE SURGERY

Treatment with neoadjuvant chemotherapy followed by interval debulking (as a primary cytoreductive procedure after a few cycles of chemotherapy) is a treatment option for advanced disease. Seventy to eighty percent of patients treated with neoadjuvant chemotherapy have partial or complete responses before interval surgery and are optimally debulked at the time of interval surgery. The surgical morbidity may be reduced compared with that associated with primary cytoreductive surgery.

The American Society of Clinical Oncology (ASCO) and the Society of Gynecologic Oncology (SGO) recently developed guidelines regarding the role of neoadjuvant chemotherapy in advanced ovarian cancer. The decision to initiate neoadjuvant treatment should be determined with the input of a gynecologic oncologist. Factors that indicate a low likelihood of achieving optimal cytoreduction and that a neoadjuvant approach should be offered include stage IV disease with metastasis in lung/mediastinum/liver, presence of bulky periportal lymph nodes or extra-abdominal lymph nodes, mesenteric retraction, and/or large tumor burden. Even in the absence of these disease sites, the goal of optimal cytoreduction is not always achievable, and identifying patients who have unresectable ovarian cancer is critical but remains a challenge.

Once the decision has been made to defer surgical intervention in favor of neoadjuvant chemotherapy, a core needle biopsy of the suspected cancer should be performed to confirm the diagnosis. Cytologic evaluation from either ascites or a pleural effusion can also be obtained to confirm the diagnosis of gyn cancer, but this is less

sensitive. These results are typically considered in conjunction with the tumor markers CA-125 and CEA. A ratio of 25:1 is consistent with a diagnosis of ovarian cancer. If biopsy or cytology is not able to be obtained, the patient may require a laparoscopic or minilaparotomy to obtain a tissue sample for diagnosis.

In addition to disease burden, factors that impact the success of cytoreduction include patients with poor performance status, older age (≥75 years age), and poor nutritional status (albumin <3.0 g/dL). Patients with recent myocardial infarction or thromboembolic disease are also better suited for neoadjuvant chemotherapy over primary debulking surgery. Women undergoing neoadjuvant chemotherapy require fewer radical procedures, including bowel surgery, and had improved perioperative outcomes compared to those undergoing primary debulking.

## HYPERTHERMIC INTRAPERITONEAL CHEMOTHERAPY

In 2018, a randomized international phase III trial demonstrated a survival advantage in patients with advanced ovarian cancer who received hyperthermic intraperitoneal chemotherapy (HIPEC) at the time of interval debulking surgery following a response/stable disease to neoadjuvant chemotherapy. Patients receiving HIPEC had a progression-free survival advantage (14.2 vs 10.7 months) and overall survival (45.7 vs 33.9 months). Though operative times were longer, the perioperative outcomes were comparable. Additional confirmatory studies are ongoing.

## SURGERY FOR RECURRENT DISEASE

When recurrence is confirmed, management options include chemotherapy, secondary cytoreductive surgical intervention, or best supportive care. The term *secondary cytoreductive surgery* has no universal definition; however, the term is currently most commonly

used to refer to surgery performed for recurrent disease after receiving primary therapy and experience a recurrence.

In a meta-analysis, Bristow and colleagues found that the only statistically significant variable independently associated with survival time was the proportion of patients undergoing complete (no gross residual disease) cytoreductive surgery. After controlling for other factors, each 10% increase in the proportion of patients undergoing complete cytoreductive surgery was associated with a 3-month increase in median cohort survival time. Similar to goals of primary surgery, the goal of surgical cytoreduction in recurrent ovarian cancer is complete gross resection to no residual disease. Platinum sensitivity, limited sites of recurrence, and good performance status are associated with improved outcomes in patients undergoing secondary surgery.

The phase III randomized trial GOG-0213 demonstrated no difference in survival outcomes in patient with platinum-sensitive recurrent disease who underwent secondary cytoreduction followed by platinum-based chemotherapy compared to those who received platinum-based chemotherapy alone. In this trial, patients were preoperatively deemed by the investigator to have disease amenable to complete gross resection, and complete (R0) gross resection was achieved in 67% of those who underwent surgery. These data conflict with the findings from the recently published phase III randomized DESKTOP-III trial in which patients with platinum-sensitive recurrent disease who had a favorable AGO score (defined as performance status of 0, ascites <500 mL, and complete resection at initial surgery) were randomized to surgery followed by chemotherapy or chemotherapy alone. In this trial, complete (R0) gross resection was achieved in 75.5% of those who were randomized to surgery, and there was a significant improvement in overall survival (53.7 vs 46 months) for those who underwent secondary cytoreduction followed by chemotherapy compared to those who received chemotherapy alone. The most benefit was seen in patients who had complete gross resection of their disease. These trials highlight both the value of preoperative assessment to carefully select patients for secondary cytoreduction and the importance of achieving an optimal cytoreduction when surgery is pursued.

Similar to secondary cytoreductive surgery, tertiary cytoreductive surgery can be offered to patient who has had long treatment-free interval/time to recurrence and the ability to achieve no residual disease at the completion of surgery as these are the most significant factors impacting survival. It should be noted that approximately one-quarter of patients undergoing tertiary debulking experience severe postoperative complications and that the only available data on tertiary cytoreduction are from retrospective series. Though limited, reports on surgery beyond tertiary debulking are available and reiterate the importance of complete cytoreduction.

# PALLIATIVE SURGERY FOR RECURRENT DISEASE

## Management of Bowel Obstruction

Twenty-five percent of ovarian cancer patients develop intestinal obstruction in the terminal phase of their illness. One of the major dilemmas facing the gynecologic oncologist is whether to operate on a patient with refractory ovarian cancer and an intestinal obstruction. Signs and symptoms of intestinal obstruction resulting from ovarian cancer include nausea and vomiting, abdominal cramping, abdominal distension, and progressive constipation. Routine abdominal x-ray should be ordered to confirm the diagnosis. In patients with early, partial obstruction, the radiographic findings may be nonspecific. CT scan of the abdomen and pelvis is useful for diagnosis and can provide information regarding sites of obstruction and degree of carcinomatosis.

Solid or multiple tumor sites may cause intestinal obstruction. In 5%-10% of patients, there is simultaneous obstruction of the small and large bowel. Colon obstruction usually occurs around the sigmoid colon because of expansion of pelvic tumors. Small bowel obstruction arises when loops of bowel become adherent to mesenteric or serosal tumor implants. When an obstruction is diagnosed, the decision of whether to operate or manage the patient nonoperatively is tempered by the fact that surgery for patients with

refractory ovarian cancer is associated with significant morbidity and mortality. Obstruction cannot be relieved in almost 20% of those undergoing surgery, and postoperative survival is disappointingly brief. Serious complication rates range from 28% to 49%, and the operative mortality is 10%. Patients should not undergo surgery if they have bulky carcinomatosis, rapidly progressive disease, multiple sites of obstruction, if performance status is poor, or if they have already received multiple regimens of chemotherapy.

For initial management of a patient with small bowel obstruction, a nasogastric tube is placed. In patients for whom no surgery is planned, a percutaneous gastrostomy is recommended. This procedure has resulted in excellent palliation for terminal-stage ovarian cancer patients, avoids the discomfort of the nasogastric tube, and allows the patient to return home. With such a device, the patient may even continue to eat for comfort; however, the nutritional benefit is essentially nil.

Colonic obstruction usually requires surgery to avoid pending perforation and a colostomy is usually performed. The selection of the site of colostomy depends on the area of obstruction and the ability to find an adequate bowel segment free of cancer. Most commonly, a transverse loop colostomy is indicated in the presence of a descending colon or sigmoid colon obstruction. There is increasing experience with the use of colonic/rectal stents as a substitute for colostomy, which appears to be a reasonable option for large bowel obstructions so that patients can avoid major surgery. Stents can be placed in a minor surgery setting.

# Gastrostomy Tube Placement

In the setting of bowel obstruction with extensive tumor for which surgery is not recommended, placement of a gastrostomy (G) tube is indicated. This procedure can be performed by an interventional radiologist, by gastroenterologists using endoscopic guidance, or surgically by the gyn oncologist.

If this cannot be placed by interventional services, a gastrostomy tube can be placed surgically. An upper abdominal midline or a vertical left subcostal incision is made and the stomach wall is

grasped with a Babcock clamp at a site of the dependent lower body of the stomach. This is lifted to the anterior abdominal wall taking care to not place this on tension. Two purse string sutures (2-0 polyglactic acid suture [Vicryl]) are placed, and a gastrostomy incision is made. A 20-French Malecot drain is brought through a separate stab incision in the left upper quadrant and placed into the gastrostomy incision. The purse string sutures are tied down around the tube. The gastrostomy site is approximated to the anterior abdominal wall peritoneum and secured using interrupted stitches. The tube is then secured to the skin using 2-0 silk sutures (**FIG. 29.8**).

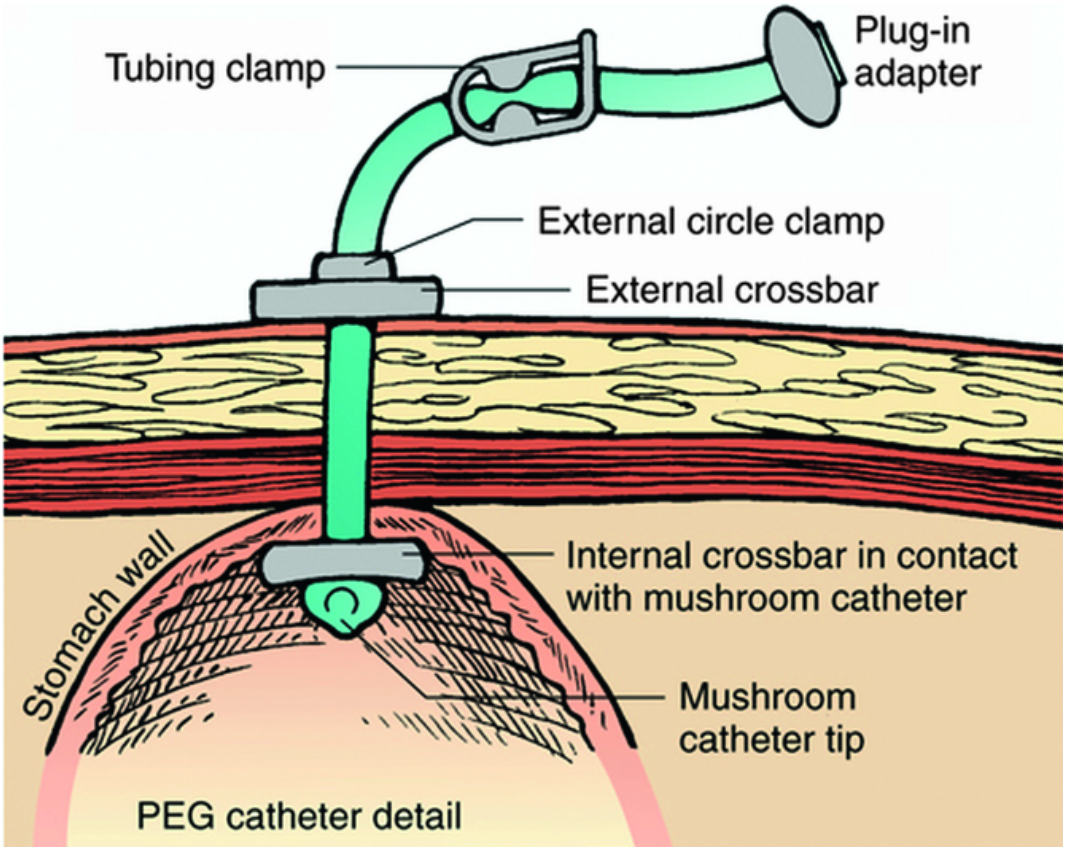



**FIGURE 29.8** Gastrostomy tube. (Reprinted with permission from Smeltzer SC, Bare BG, Hinkle JL, et al., eds. *Brunner & Suddarth's Textbook of Medical Surgical Nursing*. 11th

ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2008. Figure 36-7A.)

# SURGERY FOR OTHER OVARIAN NEOPLASMS

## Germ-Cell Tumors

Germ-cell tumors are more likely to affect adolescent and reproductive-aged women. Approximately 50%-70% of malignant germ-cell tumors are stage I. Except for dysgerminoma, for which the incidence of bilaterality is 10%-15%, bilateral ovarian germ-cell tumors are exceedingly rare. Such a finding almost always signifies advanced disease with metastatic spread from one ovary to the other or a mixed germ-cell tumor with a dysgerminoma component. Benign cystic teratoma is associated with malignant germ-cell tumors in 5%-10% of cases and may occur in one or both ovaries and can be managed with cystectomy. Therefore, unilateral salpingo-oophorectomy with preservation of the contralateral ovary and uterus, combined with surgical staging, can be performed in most patients with malignant germ-cell tumors. It is important to spare the contralateral ovary if possible in this young population. Several series have documented normal reproductive function in at least 80% of patients as well as pregnancies following fertility-sparing surgery and chemotherapy.

## Sex Cord-Stromal Cell Tumors

Most sex cord-stromal tumors are also confined to the ovary. The majority of granulosa cell tumors present as stage I disease. More than 90% of Sertoli-Leydig cell tumors are stage IA. Bilaterality occurs in <5% of cases with either tumor type. Therefore, optimal surgical management of most patients with stromal tumors consists of unilateral adnexectomy. There is no role for lymphadenectomy in patients with sex cord-stromal tumors. Endometrial biopsy or

curettage also should be performed in any young patient whose uterus is preserved because 5%-15% of patients with granulosa cell tumors develop endometrial cancer or hyperplasia.

## LOW MALIGNANT POTENTIAL TUMORS

Approximately 10%-15% of all ovarian neoplasms are low malignant potential or borderline tumors. Thirty-three to sixty percent of serous borderline tumors are limited to one ovary with extraovarian spread noted in 20%-30% of cases. Eighty to ninety percent of mucinous borderline tumors are confined to one ovary. Both endometrioid and clear cell borderline tumors are almost always stage I and occur unilaterally. For patients with borderline tumors seemingly confined to one ovary, appropriate surgical management includes unilateral salpingo-oophorectomy. Some patients have undergone ovarian cystectomy instead of unilateral adnexectomy, and these patients are at increased risk for recurrence of borderline tumors. If bilateral borderline tumors are present, portions of one or both ovaries may be preserved with ovarian cystectomy. Conservative surgery is an option, and the uterus can be preserved and patients followed. For the postmenopausal patient, bilateral salpingo-oophorectomy is recommended. The reported 5-year survival for patients with stage I borderline tumors treated with surgery alone is 95% or better.

For patients with borderline tumors and peritoneal implants, surgical excision is the mainstay of treatment. After frozen section confirmation of borderline tumor, an effort should be made to resect all gross disease. For borderline tumors, surgical staging is not indicated; however, invasive cancer may be not be detected at frozen section and be diagnosed postoperatively only on the final report. Thus, surgical staging is left to the clinical discretion of the surgeon based on frozen section results. Effort should be made to resect all visible disease, and if ovarian preservation is performed, patients should be aware of the possibility of recurrence.

# OVARIAN CANCER DIAGNOSED IN PREGNANCY

Rarely, a woman may be diagnosed with an ovarian malignancy during pregnancy. Typically, these tumors are of germ-cell, sex cord-stromal, or borderline tumors and less commonly epithelial in origin. Patients can be evaluated by laparoscopy or laparotomy and care should be taken to avoid rupture of the mass. If surgical staging is feasible, it is recommended; however, staging may be deferred due to limited abdominal/pelvic and the gravid uterus. Coordination of care between the obstetrician, neonatology team, and gynecologic oncologist is necessary.

## KEY POINTS

- The lifetime risk of ovarian cancer for a woman in the United States is 1/70 and increases to 40% if a *BRCA1* mutation and 20% if a *BRCA2* mutation is present.
- A careful evaluation of patient history, the adnexal mass using imaging, and serum CA-125 will usually identify the patient with a high risk of malignancy, and these patients should be referred to a gynecologic oncologist.
- Early-stage ovarian cancer requires comprehensive surgical staging. Fertility-sparing surgery can be offered to young women with early ovarian cancer.
- The surgical goal in advanced ovarian cancer is resection to no gross residual (R0) or optimal (R1, ≤1 cm residual) cytoreduction, which may require radical surgery, and is associated with a clear survival benefit.
- Treatment with neoadjuvant chemotherapy followed by interval debulking is a treatment option for advanced disease.
- In women who are not deemed to be optimally resectable, neoadjuvant chemotherapy followed by interval cytoreductive surgery is an option.

- Minimally invasive surgical approaches have a limited but growing role in the management of ovarian cancer and include use at the time of diagnosis, recurrence, and palliative procedures.
- Lymphadenectomy can be omitted in patients with advanced ovarian cancer unless bulky nodes are present. Large nodes should be debulked.
- Initial management of small bowel obstruction in stable patients with recurrent cancer should include placement of a nasogastric tube and supportive care. Placement of percutaneous gastrostomy tube is recommended to replace the nasogastric tube for patients who do not resolve their obstruction and do not undergo surgery.

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# SECTION VI

# Surgery for Pelvic Floor Disorders


30 TRANSVAGINAL APICAL SUSPENSIONS FOR UTEROVAGINAL PROLAPSE
Robert E. Gutman

31 SACROCOLPOPEXY
Anthony G. Visco

32 COLPORRHAPHY AND ENTEROCELE REPAIR
Cara Grimes and Patrick Popiel

33 MIDURETHRAL SLINGS AND SURGERY FOR STRESS URINARY INCONTINENCE
Renée M. Ward

34 COLPOCLEISIS
Melinda G. Abernethy

35 VESICOVAGINAL AND RECTOVAGINAL FISTULA
Chi Chiung Grace Chen and Jaime Bashore Long

# 36 Repair of Episiotomy and Complex Perineal Lacerations

Dana R. Gossett and Christina Lewicky-Gaupp

# CHAPTER 30

# TRANSVAGINAL APICAL SUSPENSIONS FOR UTEROVAGINAL PROLAPSE

Robert E. Gutman

**Uterine Preservation (Hysteropexy) vs Hysterectomy**

**Transvaginal Apical Suspension Procedures**

McCall Culdoplasty

Uterosacral Ligament Suspension

Uterosacral Hysteropexy

Manchester Procedure

Sacrospinous Ligament Fixation

Sacrospinous Hysteropexy

Anterior Vaginal Mesh Colpopexy or Hysteropexy

**Comparative Outcomes**

Uterosacral Ligament Suspension vs Sacrospinous Ligament Fixation

McCall Culdoplasty vs Uterosacral Ligament Suspension or Sacrospinous Ligament Fixation

Vaginal Hysteropexy Comparative Trials

**Choice of Repair**

Pelvic organ prolapse involves the descent of pelvic structures, including the cervix, uterus, and vaginal walls. Prevalence estimates vary (3%-50%) depending on the definition used. For example, the prevalence of prolapse is generally lower if the definition is based on symptoms (3%-6%) compared to examination findings (41%-50%). This reflects the observation that symptoms do not always correlate with anatomic severity. The symptom most reliably associated with prolapse is vaginal bulging and protrusion, which typically occurs when prolapse extends at or 0.5 cm beyond the hymen. Pelvic organ prolapse can negatively impact quality of life through associated symptoms of pelvic discomfort with vaginal bulging and protrusion, voiding dysfunction, defecatory dysfunction, and sexual dysfunction. However, up to 75% patients with prolapse at or beyond the hymen may be asymptomatic or only minimally symptomatic. Resolution of bulge symptoms is an essential component to successful prolapse surgery because it correlates with a patient's assessment of overall improvement, whereas anatomy alone does not.

The prevalence of prolapse is expected to rise with the aging of the U.S. population. There is a 12.6% estimated lifetime risk of surgery for prolapse and 13%-29% reoperation rates for recurrent prolapse. A large U.S. database study revealed a 9.6% cumulative incidence of subsequent prolapse surgery within 5 years of the index surgery; reoperation was higher (11.5%) for women at least 65 years old. Thus, prolapse surgical needs will continue to grow as women live longer and healthier lives.

Pelvic organ prolapse usually involves descent of more than one compartment of the vagina. DeLancey described defects in three levels of vaginal support: level I apical support from the uterosacral cardinal ligament complex; level II midvaginal support from anterior and posterior vaginal wall fibromuscular layer attachments laterally to the arcus tendineus fascia pelvis; and level III outlet support from the perineal membrane and perineal body with associated attachments of muscles and connective tissue (**FIG. 30.1**). The structures providing support in the midvagina are perhaps the most controversial. Many surgeons still use the term "endopelvic fascia" when describing the midvaginal support components, but histologic studies confirmed that this is not true "fascia," and more appropriate

terminology is fibromuscular layer of the vaginal wall. The levator ani muscles are thought to support all three levels by narrowing the genital hiatus and creating a nearly horizontal vaginal axis with posterior vaginal deflection. It is hypothesized that insufficient levator ani tone and support with widened genital hiatus leads to increased stress on the level I and II support structures resulting in development of worsening pelvic organ prolapse and apical descent.

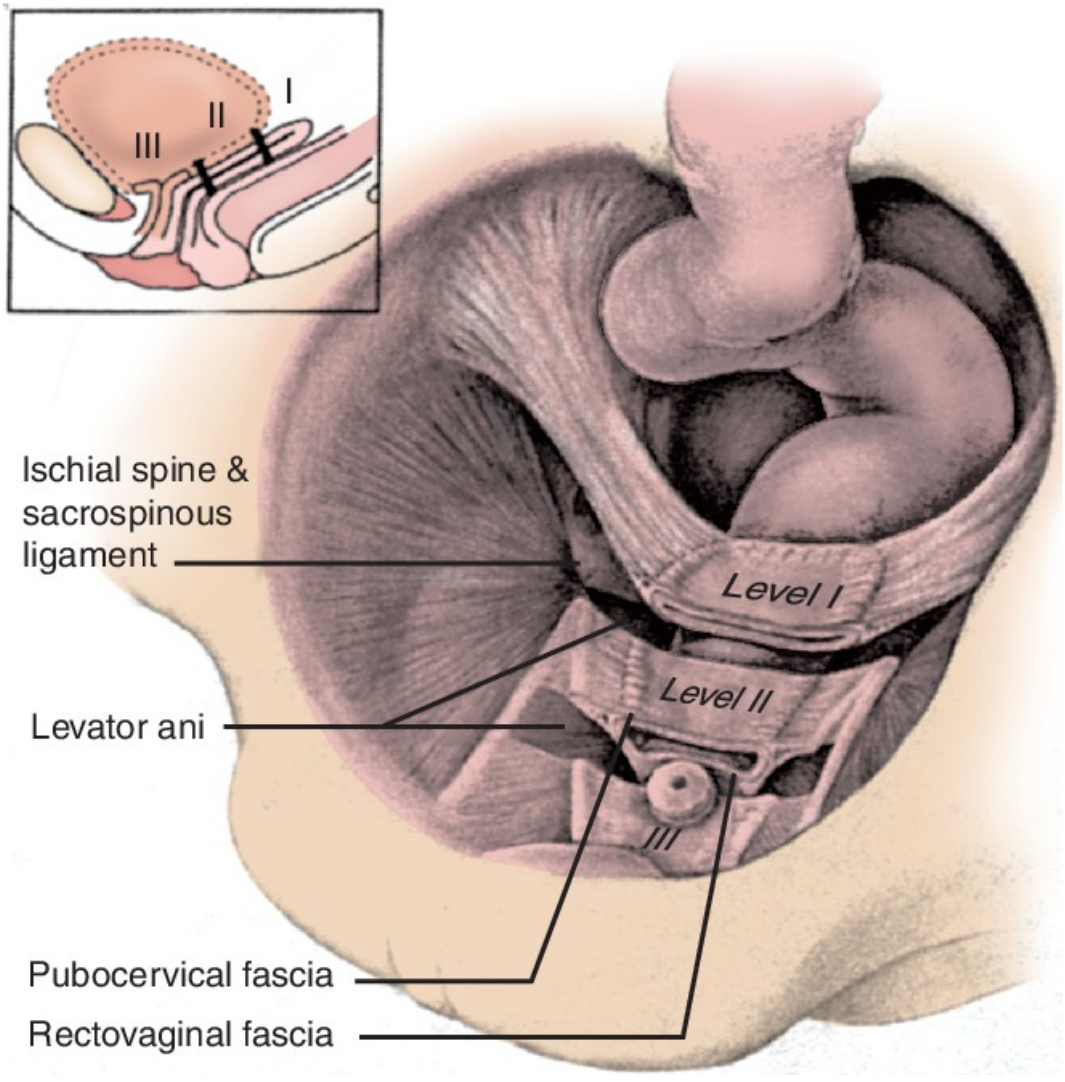


**FIGURE 30.1** Levels of support. DeLancey's biomechanical levels: level I, proximal suspension; level II, lateral attachment; and

level III, distal fusion. (Reprinted from DeLancey JO. Anatomic aspects of vaginal eversion after hysterectomy. *Am J Obstet Gynecol*. 1992;166(6 Pt 1):1717-1724. Copyright © 1992 Elsevier. With permission.)

Other than aging, the most important risk factor for development of prolapse is vaginal delivery. Results from a prospective cohort study showed an adjusted odds ratio for developing prolapse at or beyond the hymen of 5.6 (95% CI, 2.2-14.7) for those delivered by vaginal birth compared to cesarean only and 7.5 (95% CI, 2.7-20.9) with at least one operative delivery. During longitudinal follow-up, women with at least one prior vaginal delivery (OR 3.1; 95% CI, 1.4-7.1), age greater than 40 years at study enrollment (OR 1.6; 95% CI, 1.1-2.5), and a genital hiatus of at least 2 cm at enrollment (OR 2.4; 95% CI, 1.03-5.4) were associated with worsening pelvic support compared to cesarean delivery. Increased risks for prolapse development with wider genital hiatus and operative vaginal delivery may be markers for larger babies and more severe birth trauma resulting in stretching, tears, denervation, or even detachments of the levator ani muscles. Growing evidence links levator ani defects seen on magnetic resonance imaging to the presence and severity of prolapse. Other evidence-based risk factors for prolapse development include family history (with genetics and pelvic morphology potentially playing a role), obesity, and prior hysterectomy. There is less evidence regarding the impact of conditions that cause chronic increased intra-abdominal pressure, such as chronic cough, straining with bowel movements, and work or exercise involving repetitive heavy lifting. Several of the risk factors previously mentioned are also risk factors for recurrent prolapse following repair (eg, wide genital hiatus, levator ani defects, and obesity or other causes of chronic increased intra-abdominal pressure). Ultimately, the most important risk factors for recurrent prolapse appear to be a history of prior unsuccessful prolapse surgery and more severe prolapse.

The most common anatomic location for prolapse is the anterior vaginal wall. However, anatomic studies have shown that ~50% of anterior vaginal prolapse can be attributed to apical descent. Not surprisingly, risk of reoperation for prolapse increases in the absence of a concomitant apical support procedure. Among a large sample of Medicare beneficiaries, reoperation rates were higher for those who underwent anterior colporrhaphy alone compared to anterior colporrhaphy with apical support procedure (20.2% vs 11.6%, $P < .01$). Apical support is generally considered the cornerstone of any good prolapse repair, and every effort must be made to increase awareness of its importance during prolapse surgery.

A variety of options exist for surgical correction of apical vaginal support. Over the past decade, there has been a shift toward minimally invasive surgery for prolapse, with vaginal surgery generally being considered the least invasive route for hysterectomy and prolapse repair. This chapter focuses on transvaginal apical suspensions. Subsequent chapters review anterior and posterior colporrhaphy and enterocele repair (Chapter 32, Colporrhaphy and Enterocele Repair) as well as alternative apical prolapse repairs, including colpocleisis (Chapter 34, Colpocleisis) and sacrocolpopexy (Chapter 31, Sacrocolpopexy).

## UTERINE PRESERVATION (HYSTEROPEXY) VS HYSTERECTOMY

Uterine preservation can be considered at the time of prolapse repair, as the uterus is a passive structure in the development of pelvic organ prolapse. Yet prolapse is one of the most common indications for the almost 500 000 inpatient hysterectomies performed in the United States each year. Surveys suggest that the majority of patients presenting for prolapse would choose uterine preservation assuming equal surgical outcomes. However, in many cases, this preference is based on misperceptions, such as that hysterectomy will negatively impact mood, relationships, quality of

life, sex drive, and weight. While patients can be reassured regarding these concerns, some patients consider the uterus to be an integral component to their sense of identity and elect uterine conservation. Moreover, others have concerns regarding hysterectomy complications. It is important to elicit patient goals, provide adequate education, and consider preferences and beliefs when planning a surgery for pelvic organ prolapse and obtaining informed consent.

Potential benefits of hysteropexy compared to hysterectomy at the time of vaginal suspension include decreased blood loss, shorter operating time, and more rapid recovery compared to hysterectomy. Also, hysteropexy has not been associated with a risk of early menopause, while a large prospective cohort study showed a twofold increased risk of menopause over a 5-year time period with hysterectomy alone compared to nonsurgical controls, even with ovarian conservation. The quantity and quality of hysteropexy studies are growing, and most show short-term safety and efficacy. However, most lack controls and contain heterogeneous techniques and definitions of success.

Uterine conservation is not appropriate for all patients. Strict selection criteria should be employed when considering candidates for uterine preservation in order to limit the need for subsequent hysterectomy. Women interested in future fertility and those uncertain regarding reproductive plans should be offered a pessary; surgery should be reserved for cases that fail conservative management or after completing childbearing. Also, because a future hysterectomy is likely to be technically challenging after hysteropexy, uterine conservation should not be recommended for patients at increased risk for uterine and endometrial disease. Women with increased risk for endometrial, cervical, or ovarian cancer should probably be advised to undergo hysterectomy (and possibly removal of the tubes and ovaries) during prolapse repair. Risk factors for endometrial hyperplasia and cancer include obesity (up to threefold increased risk), hereditary nonpolyposis colorectal cancer (Lynch syndrome—60% lifetime risk), and those with postmenopausal bleeding even with a negative workup (13% risk of unanticipated pathology). Women with BRCA 1 and 2 mutations are

at increased risk of ovarian cancer and theoretically increased risk of fallopian tube and serous endometrial cancer. Women with a history of estrogen receptor–positive breast cancer usually opt for bilateral oophorectomy to decrease the risk of recurrent breast cancer. Findings of endometrial hyperplasia with or without atypia suggest the need for concomitant hysterectomy due to a 5%-25% risk of developing endometrial cancer. Similar recommendations should be considered for patients taking tamoxifen or other medications that increase the risk of endometrial hyperplasia. Also, those with current or recent cervical dysplasia should avoid uterine and cervical preservation. Hysteropexy should be avoided in patients with dysmenorrhea and irregular menstrual bleeding from enlarged fibroids, adenomyosis, and other causes of abnormal uterine bleeding that would increase the potential for future interventions. Lastly, patients with cervical elongation should consider hysterectomy or at least partial trachelectomy (cervical shortening) to improve outcomes.

# TRANSVAGINAL APICAL SUSPENSION PROCEDURES

The goals for prolapse surgery should be to restore anatomy and improve or resolve associated symptoms. In order to restore anatomy, the majority of transvaginal apical suspension procedures rely on the uterosacral or sacrospinous ligaments for support. The iliococcygeus suspension has also been promoted as a transvaginal apical suspension procedure but is not as popular due to concerns regarding vaginal shortening. Both McCall culdoplasty and uterosacral ligament suspension procedures utilize the uterosacral ligaments for support and are typically performed intraperitoneally and bilaterally to align the apex along the normal vaginal axis. Alternatively, the sacrospinous ligament, which lies below the coccygeus muscle, is a durable, reliable ligament; fixation to this ligament, however, deflects the vagina slightly more posteriorly. Sacrospinous ligament suspension is typically performed extraperitoneally and as a unilateral suspension, deviating the

vaginal apex to the right side. The following sections review the steps of the McCall culdoplasty, uterosacral ligament suspension, and sacrospinous ligament fixation procedures, including success rates and complications.

## McCall Culdoplasty

The McCall culdoplasty or “posterior culdoplasty” was originally described in 1957 as an apical support procedure, enterocele repair, and adjunct to hysterectomy that might prevent prolapse. Following vaginal hysterectomy, the enterocele sac is obliterated using a series of nonabsorbable sutures, which pass through each uterosacral ligament and include the intervening cul-de-sac peritoneum. Sequential sutures are placed proximally until the entire enterocele is closed. McCall recommended using at least three internal (intraperitoneal) nonabsorbable sutures; however, the total number depends on the size of the enterocele. Internal sutures are placed and held. Absorbable sutures are then passed through the posterior vaginal epithelium, through each uterosacral ligament (excluding the intervening tissue), and then through the posterior vaginal epithelium on the contralateral side. The most proximal suture is placed at the vaginal apex to ensure maximal length. The internal sutures are tied first, creating a shelf that suspends the vaginal apex once the external sutures are tied down. McCall suggested that vaginal length would be increased by not excising the enterocele sac or posterior vaginal epithelium.

Since the original procedure was introduced, several modifications have been made, including varying the number of sutures, shortening the uterosacral ligaments, excising the enterocele sac and redundant posterior vaginal epithelium, and incorporating intervening cul-de-sac peritoneum with external sutures. Whether it is called the Mayo culdoplasty, modified McCall culdoplasty, Mayo-McCall culdoplasty, or high McCall culdoplasty, the main principle of the original McCall culdoplasty is the plication of the uterosacral ligaments in the midline to provide apical support and to cure or prevent enterocele formation following vaginal hysterectomy.

We recommend the procedure include at least two to three sutures. When using nonabsorbable sutures, the surgeon places one or two sutures internally, with a delayed absorbable suture externally (**FIG. 30.2**). However, when using all absorbable sutures, the surgeon has the option of placing all sutures externally. Suture placement is facilitated by grasping the proximal uterosacral ligament with an Allis clamp, with traction away from the sidewall. Palpation of the ischial spine should confirm that the planned suture site is located posterior to the spine. This may prevent both entrapment of sacral nerve roots and ureteral kinking or injury. Excision of the redundant posterior vaginal wall and enterocele sac is performed at the discretion of the surgeon (**FIG. 30.3**). This will inherently narrow the vaginal apex; care must be taken to avoid creating a functionally shortened vagina and potential dyspareunia. Internal sutures are tied down first followed by external sutures (**FIG. 30.4**). Vaginal cuff closure prior to tying down the external sutures may be easier, but the surgeon must be careful to avoid trapping the external sutures during this step (**BOX 30.1**).

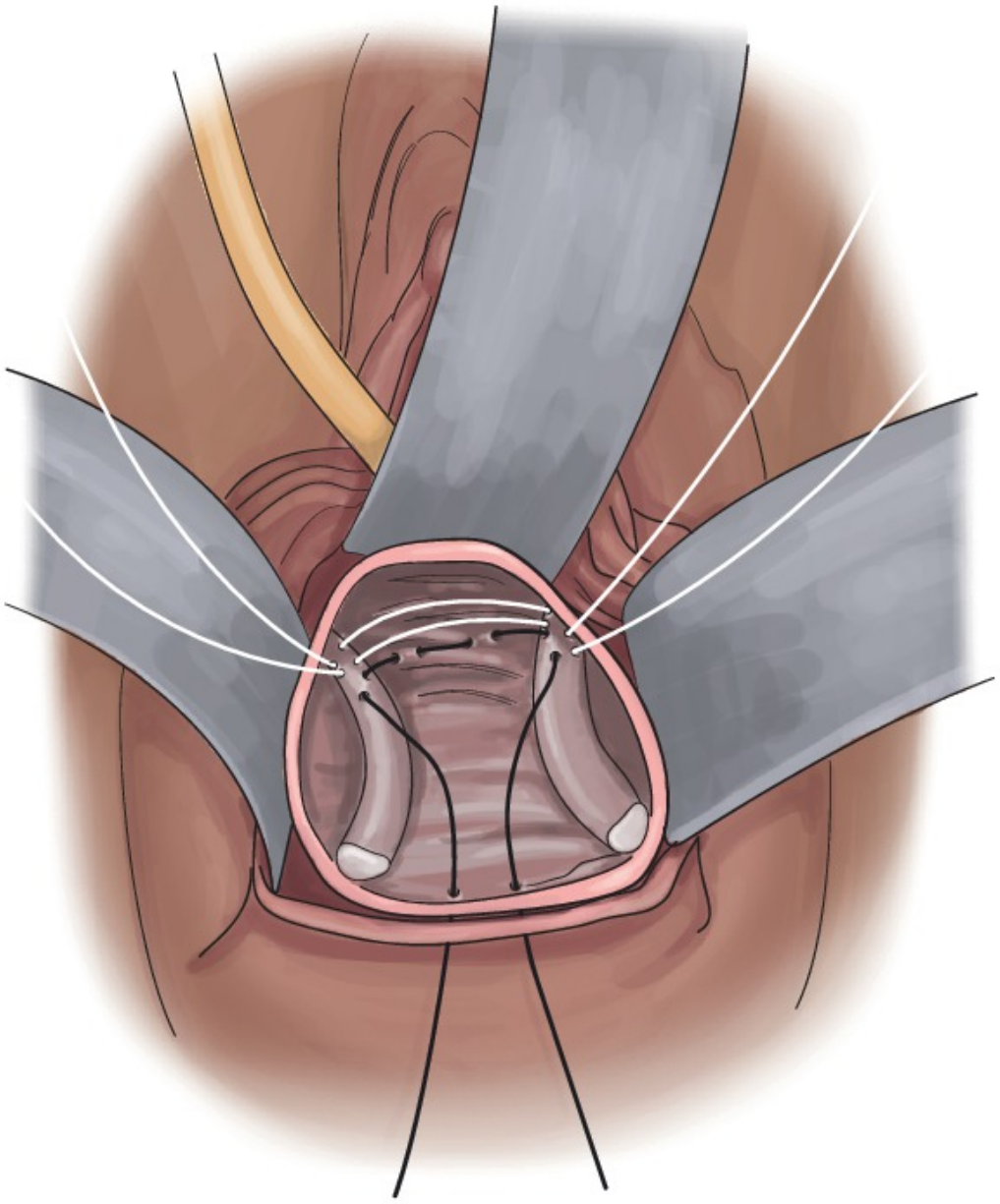

**FIGURE 30.2** McCall culdoplasty. Two internal sutures (permanent) and one external suture (delayed absorbable) have been placed.

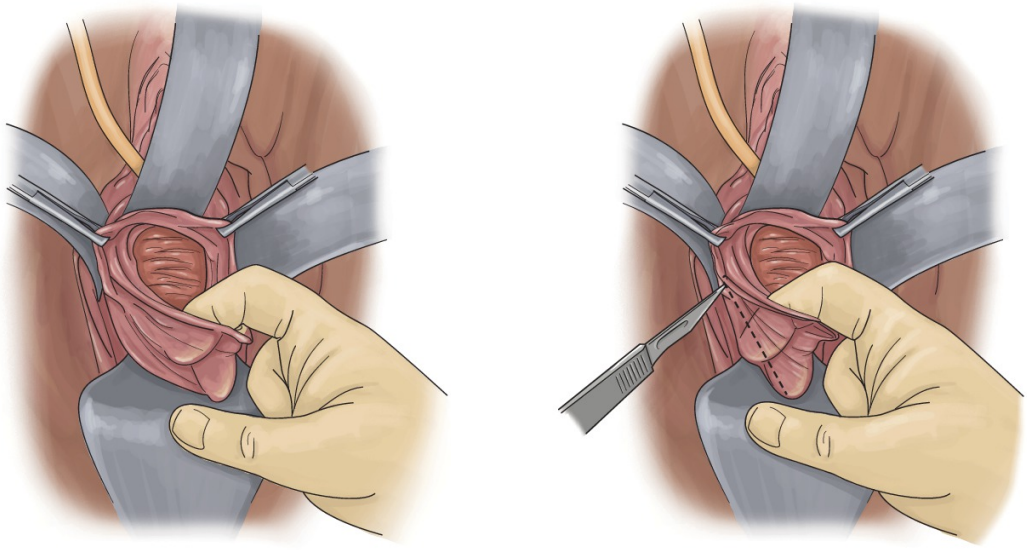

**FIGURE 30.3** With the vaginal cuff open, the surgeon palpates the posterior cul-de-sac and enterocele. The redundant wedge of posterior vaginal wall and peritoneum is removed.

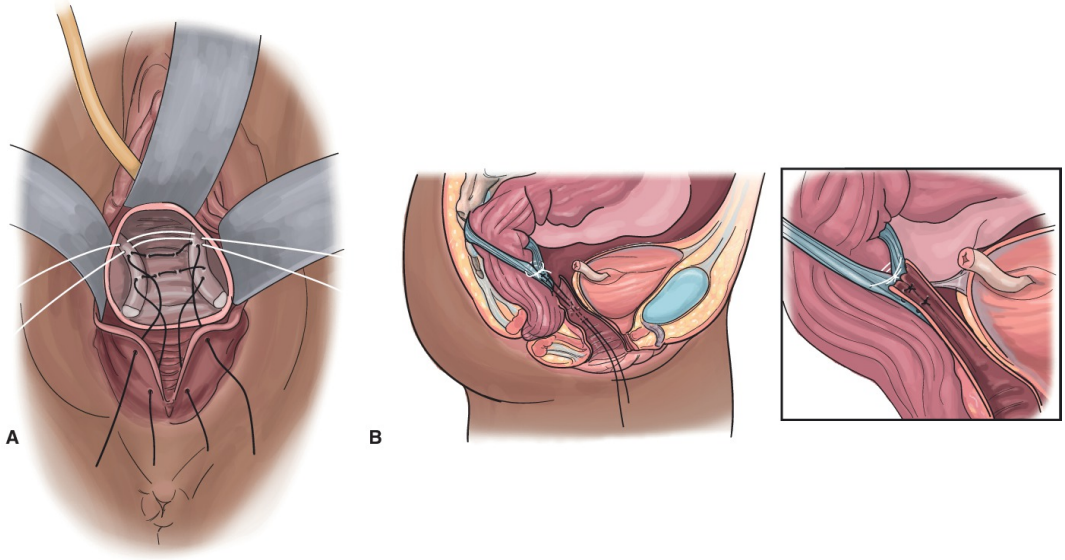


**FIGURE 30.4** **A.** Placement of internal (nonabsorbable) and external (delayed

absorbable) McCall sutures. A wedge of posterior vaginal wall was previously removed. **B.** Cross section of the upper vagina and vaginal vault before tying these sutures. The **inset** illustrates the final result, after the sutures are tied.

## BOX 30.1 STEPS IN THE PROCEDURE

### McCall Culdoplasty

- Pack the bowel out of the pelvis as indicated using moist laparotomy sponges or a Kerlix sponge.
- Expose the uterosacral ligaments with retractors.
- Grasp the vaginal cuff at the uterosacral ligament insertion (pedicles held during vaginal hysterectomy) using an Allis or Kocher clamp, and apply traction.
- Palpate the ischial spine, and identify and grasp the proximal uterosacral ligament on each side using a long Allis clamp.
- If desired, excise the enterocele sac and/or redundant posterior vaginal epithelium.
- Place internal nonabsorbable or delayed absorbable sutures through the dorsal/posterior aspect of each uterosacral ligament including the intervening cul-de-sac peritoneum to obliterate the enterocele sac. Place distal sutures first; hold and apply traction followed by proximal sutures.
- Place external delayed absorbable sutures through the posterior vaginal epithelium and each uterosacral ligament exiting the contralateral posterior epithelium. The new vaginal apex should be located at the most proximal aspect of the uterosacral ligaments.

- Perform anterior colporrhaphy as indicated.
- Remove any inserted packing.
- Tie internal sutures first followed by cuff closure and then external sutures.
- Cystoscopy confirms ureteral patency and excludes lower urinary tract injury.
- Perform posterior vaginal wall repair as indicated followed by rectal examination to exclude injury.

## *Surgical Outcomes*

Data for this commonly performed vaginal apical support procedure (limited to retrospective series and cohorts) reveal high success rates and low reoperation rates for recurrent prolapse. The largest series ($n$ = 693) demonstrated 82% satisfaction and 5.2% reoperation. Two years after vaginal hysterectomy and McCall culdoplasty, outcomes were similar when comparing patients with advanced ($n$ = 38) vs less severe ($n$ = 273) prolapse, although more anterior failures (18.4% vs 6.2%, $P$ = .02) were observed in the advanced prolapse group. Ureteral obstruction from kinking or injury is reported in <3% of cases, and a retrospective series of 411 Mayo culdoplasty repairs showed minimal risk (<1%) using the dorsal and posterior aspect of the uterosacral ligament. Plication of the uterosacral ligaments may contribute to the development dyspareunia seen postoperatively in up to 22% of cases.

# Uterosacral Ligament Suspension

This procedure is distinguished from the McCall culdoplasty by the lack of a midline plication. Despite the first publication of the technique by Miller in 1927, modifications that avoided midline plication did not gain popularity until Jenkins in 1997 and Shull in 2000 published their techniques. These surgeons promoted a procedure based on the suspension of the vaginal apex to the ipsilateral intraperitoneal portion of the uterosacral ligament (with

sutures placed proximal to the level of the ischial spines to restore the vaginal apex to its normal physiologic position). While typically done at the time of vaginal hysterectomy, this procedure can also be implemented in the setting of uterine conservation or for posthysterectomy vault prolapse.

After packing the bowels, a large Breisky-Navratil retractor lifts the bladder, packs, and intestines anteriorly, with a second retractor to deflect the rectum posteriorly and medially, thus exposing the course of the uterosacral ligament along the pelvic sidewall. The vaginal cuff is grasped at the uterosacral insertion point with an Allis or Kocher clamp. Sometimes the ligament is detached or attenuated at this location and must be identified proximally. Once identified, another long Allis clamp is placed on the proximal uterosacral ligament to provide traction away from the pelvic sidewall and underlying sacral nerve roots. Palpation of the ischial spine permits confirmation that the planned suture location sites on the ligament are at or proximal to level of the ischial spine as well as posterior and dorsal to the spine. The latter location is important to prevent potential ureteral obstruction via kinking or injury. Additional attempts can be made to palpate the course of the ureter by sweeping a fingertip along the pelvic sidewall ventrally/anteriorly to dorsally/posteriorly.

All sutures are placed laterally to medially through the uterosacral ligament ~1 cm apart and held. If an anterior colporrhaphy is needed, it is generally easier to perform this prior to the vaginal suspension. The ends of the uterosacral ligament suspension sutures are then advanced through the fibromuscular layer of the anterior and posterior vaginal cuff using either double-armed sutures or a free Mayo needle. Sutures are placed through the anterior vaginal wall fibromuscular layer at the cuff incision, followed by the ipsilateral uterosacral ligament and then through the posterior vaginal wall fibromuscular layer. Shull described three sutures inserted on each side with the more proximal sutures secured medially and the distal sutures secured laterally along the vaginal cuff for transverse closure (**FIG. 30.5**). The packing is removed, and the sutures are tied elevating the vaginal cuff (**FIG. 30.6**). Sutures tails are held long and later trimmed after cystoscopy

confirms ureteral patency. If a posterior colporrhaphy is indicated, this can be performed either after the vaginal colpopexy and cuff closure or prior to securing the uterosacral ligament suspension sutures to the cuff. A rectal examination should be performed at the end of the procedure to exclude injury during uterosacral suspension and posterior colporrhaphy (**BOX 30.2**).

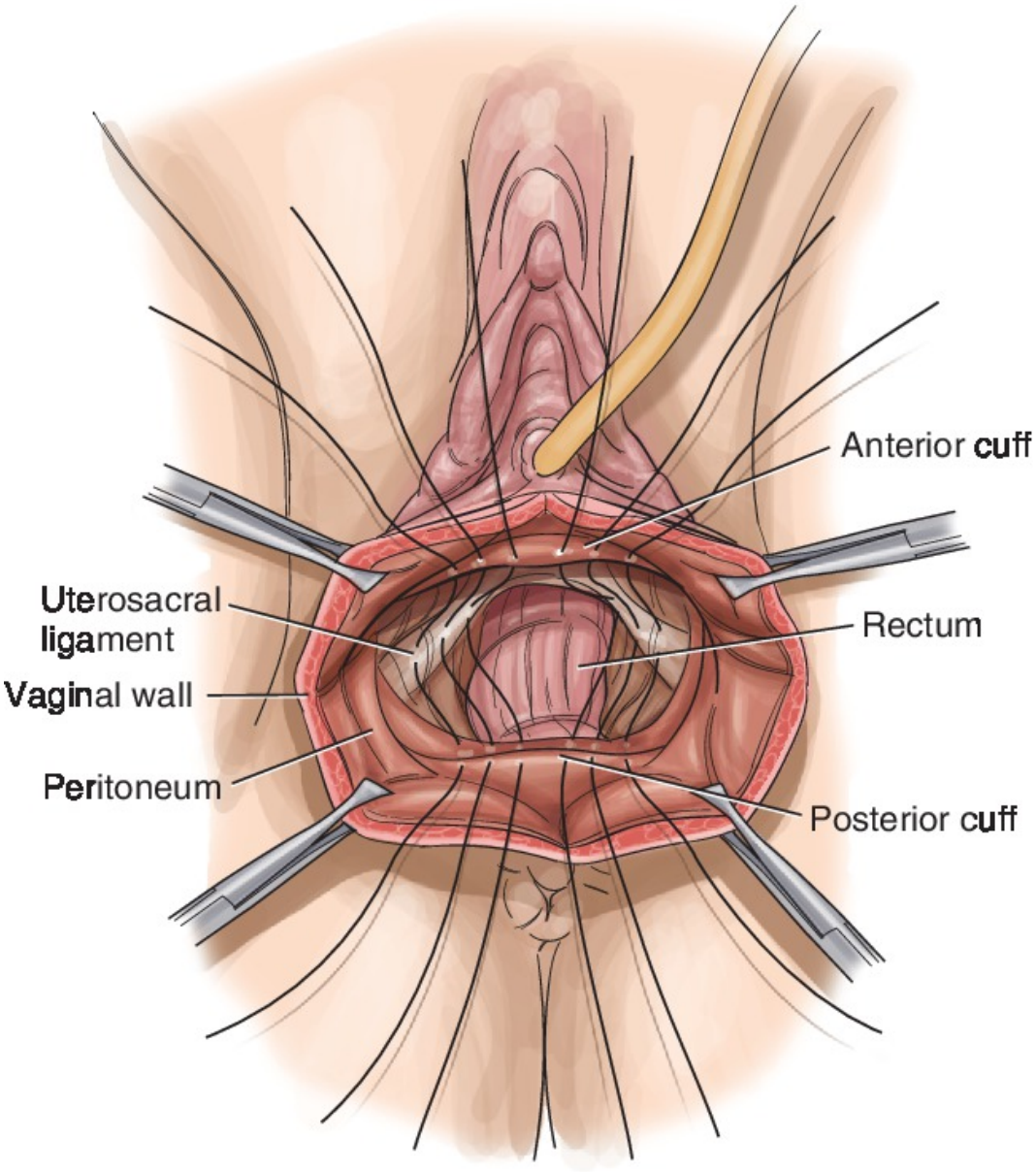


**FIGURE 30.5** The uterosacral ligament sutures are placed through the vaginal cuff.

One end of each suture is placed through the anterior cuff and one through the posterior cuff, including the peritoneum and the entire thickness of the vaginal wall with the exception of the epithelium. The suture that was placed more superiorly on the ligament is passed through the vaginal cuff more medially.

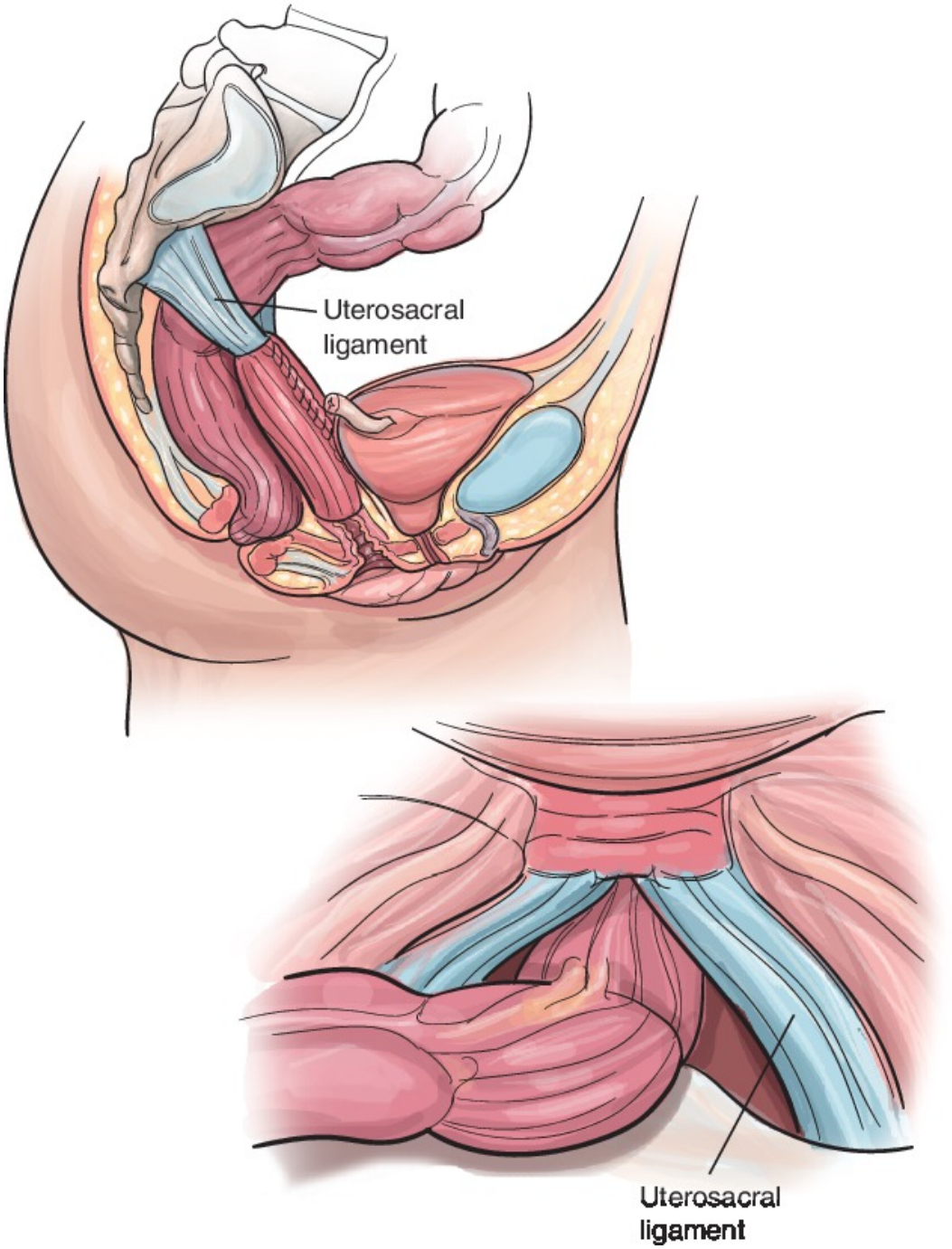


**FIGURE 30.6** Uterosacral ligament suspension. **Top.** Sagittal view of the uterosacral ligaments secured to the vaginal cuff following anterior colporrhaphy. **Bottom.**

Intra-abdominal view of the tied suspension sutures.

## BOX 30.2 STEPS IN THE PROCEDURE

### Uterosacral Ligament Suspension

- Pack the bowel out of the pelvis as indicated using moist laparotomy sponges or a Kerlix sponge.
- Expose the uterosacral ligaments with retractors.
- Grasp the vaginal cuff at the uterosacral ligament insertion (pedicles held during vaginal hysterectomy) using an Allis or Kocher clamp, and apply traction.
- Palpate the ischial spine, and identify and grasp the proximal uterosacral ligament on each side using a long Allis clamp.
- Place two or three sutures laterally to medially through the uterosacral ligament and hold. Space sutures ~1 cm apart with the most distal at the level of the ischial spine.
- Perform anterior colporrhaphy as indicated.
- Secure the ends of the uterosacral ligament suspension sutures through the fibromuscular layer of the anterior and posterior vaginal cuff using either double-armed sutures or a free needle. Proximal sutures are placed medially and distal sutures laterally. Nonabsorbable sutures should exclude the epithelium, while delayed absorbable sutures can be placed through the epithelium.
- Remove any inserted packing.
- Tie sutures elevating the vaginal cuff and hold tails long.
- Cystoscopy confirms ureteral patency and excludes lower urinary tract injury.

- Trim suture tails, close vaginal cuff as indicated, perform posterior vaginal colporrhaphy and/or enterocele repair as indicated followed by rectal examination to exclude injury.

Variation exists in the number of sutures placed on each side and the type of suture used. Some surgeons place only one or two sutures on each side. Some surgeons use all nonabsorbable sutures and bury the knots below the vaginal cuff epithelium, some use a combination of absorbable and nonabsorbable sutures with the absorbable sutures placed laterally, and still others use all delayed absorbable sutures.

An argument in favor of absorbable sutures is that exposure of nonabsorbable sutures occurs in as many as 36.1% of patients. While there are no randomized trials on this topic, we believe that the evidence favors using delayed absorbable sutures for uterosacral ligament suspensions. Of published case series, all but one showed no differences in success rates comparing absorbable and nonabsorbable sutures. Unger performed the largest retrospective review of patients undergoing uterosacral suspension with three different suture types and configurations: two per side, absorbable/nonabsorbable (*n* = 361); three per side, all delayed absorbable (*n* = 454); and combined uterosacral/McCall technique, absorbable/nonabsorbable (*n* = 168). The composite recurrence rate was 14.4% and was not associated with the number and type of suture used. Granulation tissue occurred in 10.7% of patients with no differences based on suture type. Suture erosions requiring office excision were more common in the nonabsorbable group, but this difference was not statistically significant (6.2% vs 2.4%, *P* = .10). A recent retrospective cohort compared patients undergoing uterosacral suspension with either all absorbable (*n* = 188) or mixed absorbable/nonabsorbable (*n* = 54) sutures. Approximately two-thirds of the absorbable group used delayed absorbable suture, and 93% had only one suture per side. Most of the nonabsorbable group had two sutures per side (83%) using combined polypropylene (Prolene) and polyglyconate (Maxon) (85%). Composite anatomic failures (17.8%, no prolapse beyond hymen, no retreatment) were not different between groups (OR 1.11; 95% CI, 0.5-2.5), even

though fewer sutures were used in the absorbable group. Kasturi also showed no differences in apical support based on suture type (65 delayed absorbable vs 50 nonabsorbable) following uterosacral suspension with three sutures per side. However, braided polyester (Ethibond) was responsible for all 22% of suture erosions. Of potential concern is that one study demonstrated more recurrent prolapse beyond the hymen (6% vs 1%, *P* = .03) when using delayed absorbable sutures (*n* = 141) vs permanent sutures (*n* = 105) during uterosacral suspension with three sutures per side.

Another advantage of absorbable suture is that the tails do not have to be buried below the cuff and can be advanced through the full-thickness vaginal cuff epithelium of the anterior and posterior walls. Because the suture tails are located inside the vaginal lumen, the surgeon has easier access if removal is required. In addition, these sutures often are sufficient to close the cuff (with no or limited additional sutures required).

One disadvantage is that the delayed absorbable suture tails may take 3-6 months or longer to fully dissolve, which may cause the patient or her partner short-term discomfort when they resume sexual intercourse.

# *Surgical Outcomes*

Most of the evidence for uterosacral ligament suspension comes from uncontrolled retrospective case series, showing high overall anatomic success rates (mean 85%, range 48-96%), low reoperation rates (mean 5.8%, range 0%-12%), and good prolapse symptom relief (82%-100%). A meta-analysis and systematic review by Margulies revealed pooled anatomic success rates (<stage 2) of 98.3% (95% CI, 95.7%-100%) for the apex, 81.2% (95% CI, 67.5%-94.5%) for the anterior wall, and 87.4% (95% CI, 67.5%-94.5%) for the posterior wall. More advanced preoperative anterior vaginal prolapse (stage 3 vs stage 2) was associated with lower anatomic success (66.8% vs 92.4%, *P* = .06).

An important complication of uterosacral suspension is ureteral obstruction via kinking or injury that occurs between 1% and 11% of the time. Cystoscopy should be performed after the uterosacral

suspension sutures are tied as traction on the sutures with the cuff open may not reliably predict obstruction at the end of the procedure. A large retrospective series of over 900 cases at a single institution showed ureteral kinking in 4.5%, all of which were detected with intraoperative cystoscopy and resolved with suture removal. Systematic review indicates low (0.6%) rates of ureteral injury requiring reimplantation. Other complications, such as bladder or bowel injury and bleeding requiring blood transfusion, were <1%.

Another potential complication associated with uterosacral ligament suspension is the buttock, thigh, or external vulvar/perineal pain and paresthesias. Reported incidence of this complication ranges from 1.1% to 6.8%. Anatomic studies have shown that the S2 and more likely S3 nerve roots are vulnerable (**FIG. 30.7**). It has been suggested that the risk of entrapment may increase with deeper suture placement as well as more proximal placement (closer to the sacrum). Elevating the ligament away from the pelvic sidewall with an Allis clamp, limiting the suture depth, and placement within 2 cm proximal to the level of the ischial spine may alleviate this risk. The majority of neuropathic symptoms are self-limited and generally resolve with observation, so suture removal should be reserved for severe intractable cases lasting more than 1-2 weeks in order to decrease the risk of long-term sequelae.

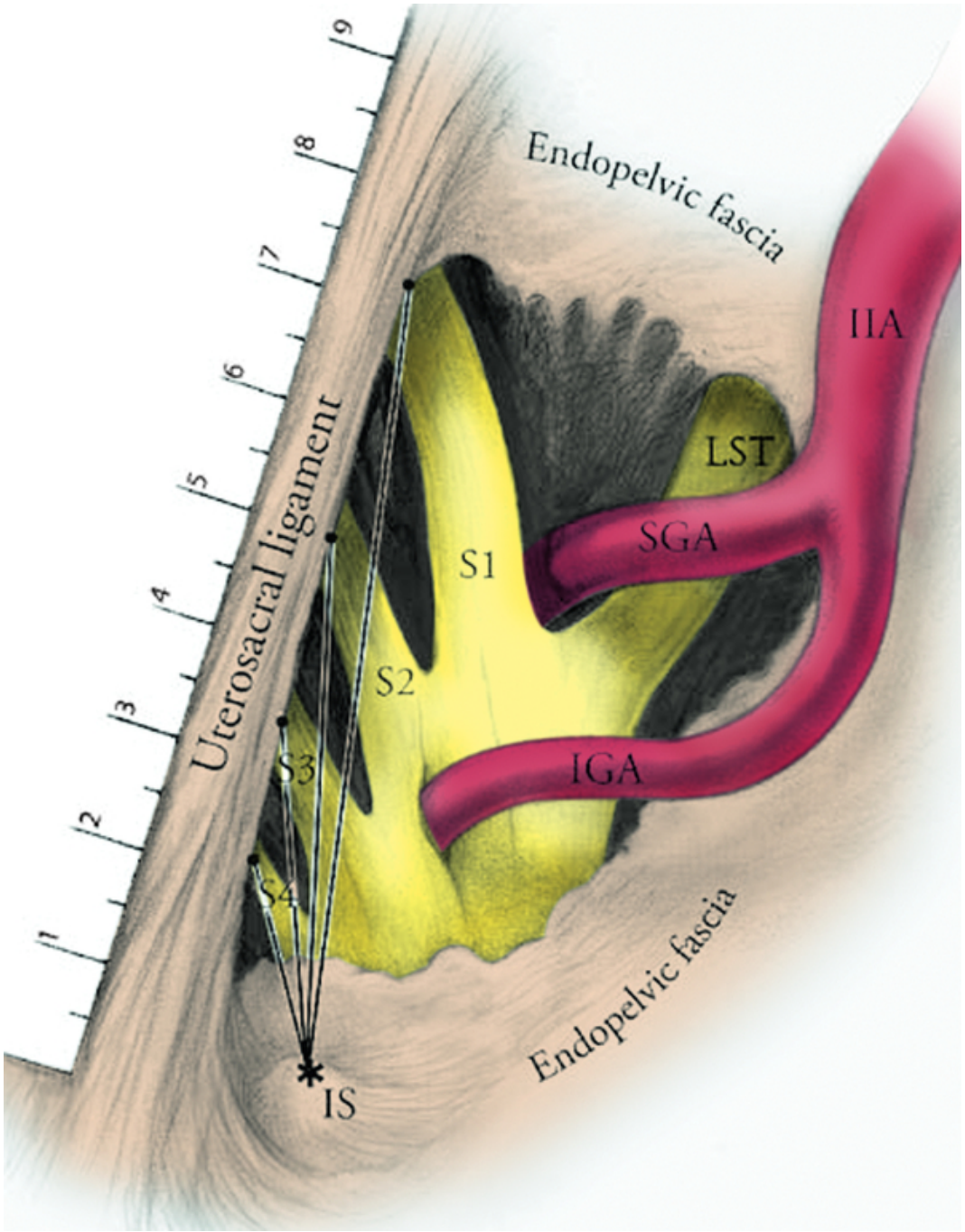


**FIGURE 30.7** The sacral nerve roots course under the left uterosacral ligament as they pass laterally to exit the greater sciatic foramen. The S4 nerve root passes under the ligament <1 cm from the ischial spine, while

the S3 root and S2 root pass under the ligament 1.5 and 2.6 cm cephalad to the spine, respectively. (Reprinted by permission from Springer: Siddique SA, Gutman RE, Schön Ybarra MA, et al. Relationship of the uterosacral ligament to the sacral plexus and to the pudendal nerve. *Int Urogynecol J Pelvic Floor Dysfunct*. 2006;17(6):642-645. Copyright © 2006 International Urogynecology Journal.)

## Uterosacral Hysteropexy

Uterosacral suspensions have been described for uterovaginal prolapse with uterine preservation, but the majority have been performed laparoscopically. There are only a few publications and descriptions of vaginal uterosacral hysteropexy. This procedure is feasible after access is obtained to the uterosacral ligaments via a posterior colpotomy incision. One to three uterosacral ligament suspension sutures are placed on each side as previously described. Usually, delayed absorbable sutures are transfixed to the posterior fornix and cervix, including the colpotomy epithelium. Distal sutures are placed laterally and proximal sutures medially. Tying the sutures closes the colpotomy incision and lifts the uterus and posterior cervix as the ligaments are shortened and plicated on each side (**FIG. 30.8A and B**). The technique for laparoscopic uterosacral suspension is similar.

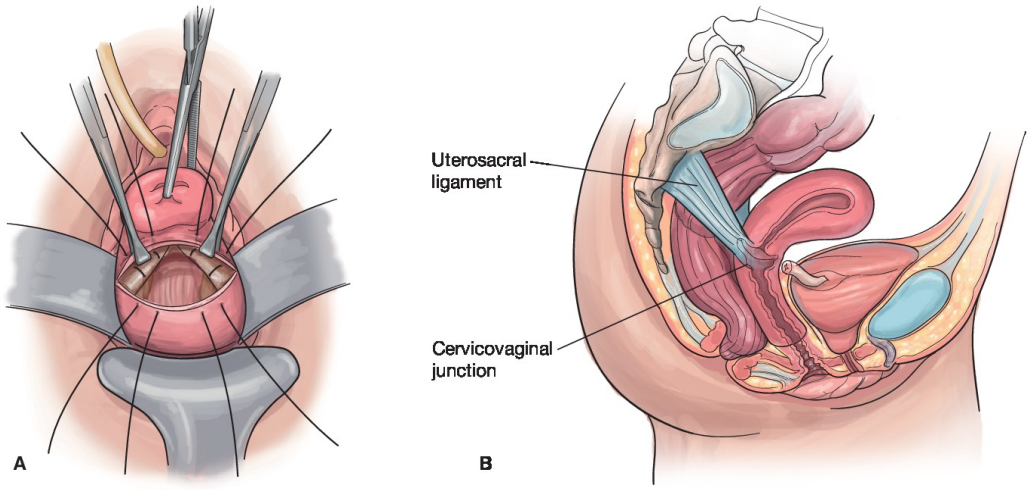


**FIGURE 30.8** Uterosacral hysteropexy. **A.** Uterosacral ligaments are accessed via a colpotomy incision, in a modification of classic Shull technique. Two sutures have been placed on each side. **B.** Sagittal view, showing the posterior vaginal fornix and cervix supported to the uterosacral ligaments.

## *Surgical Outcomes*

Romanzi performed a retrospective cohort study comparing 100 patients who underwent vaginal uterosacral hysteropexy to 100 patients undergoing vaginal hysterectomy with uterosacral suspension. Similar apical (96% vs 97%), anterior (87% vs 94%), and posterior (98% vs 100%) support outcomes were noted. Milani reported a feasibility study for the first 20 patients undergoing a similar technique. Of five (25%) recurrences, two were attributed to the development of severe cervical elongation. Both of these studies permitted “trachelorrhaphy” for cervical hypertrophy. Another recent retrospective case series by Aserlind included 40 patients undergoing uterosacral hysteropexy; 20% underwent concomitant

trachelectomy for cervical elongation. At a mean follow-up of 17 months, all patients had significant improvement of anatomical support with no reoperations for recurrent prolapse.

# Manchester Procedure

The Modified Manchester procedure is an older prolapse repair that improves apical support via amputation of the cervix (with preservation of the uterine corpus) and extraperitoneal reattachment of the uterine body to the cardinal and uterosacral ligaments (**FIG. 30.9**). As enthusiasm grows for uterine conservation, this procedure is gaining renewed interest despite primarily being a treatment for cervical elongation. The available evidence suggests that better surgical options may include LeFort colpocleisis, vaginal sacrospinous, and uterosacral hysteropexy.

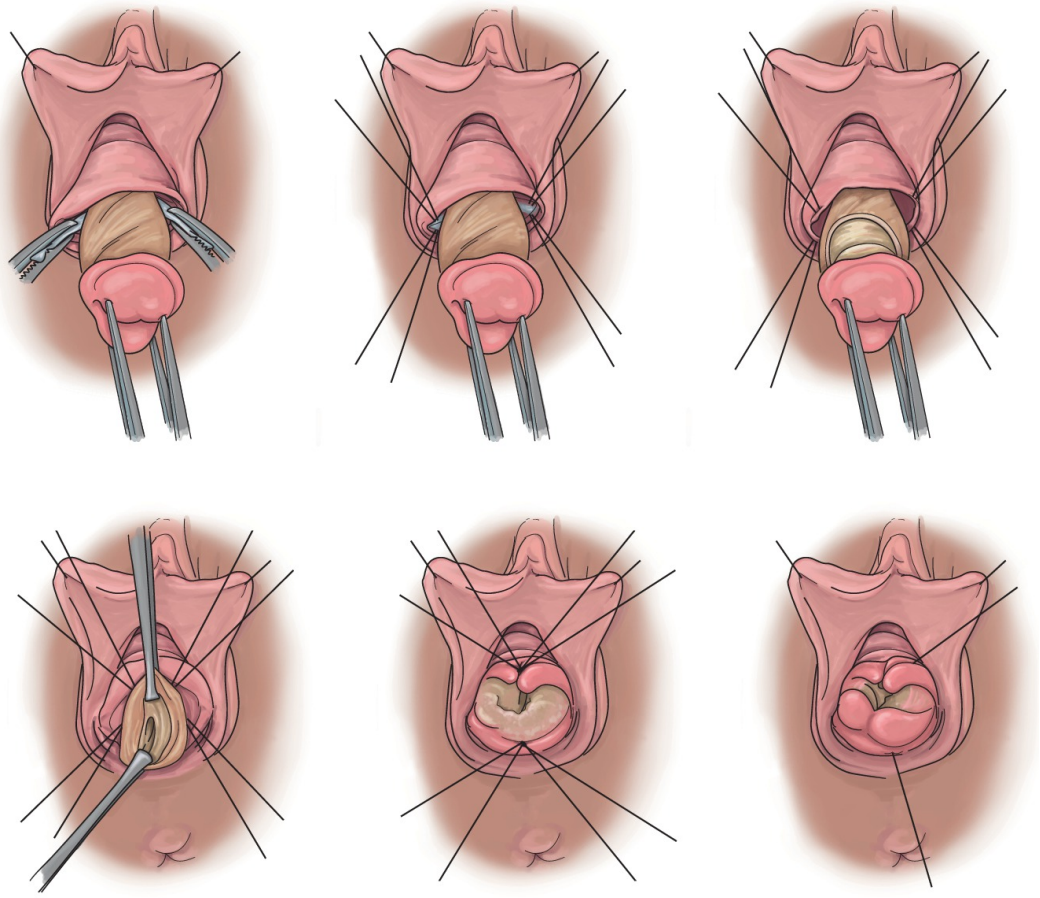

**FIGURE 30.9** Manchester procedure.

The initial steps are similar to a vaginal hysterectomy, with anterior and posterior incisions at the cervicovaginal junction. The vesicovaginal and rectovaginal spaces are developed as the bladder is dissected anteriorly and the rectum posteriorly. The uterosacral and cardinal ligaments are clamped, transected, and ligated. The cervix is then amputated and the cardinal ligaments plicated and transfixed to the cervix anteriorly and the uterosacral ligaments plicated and transfixed posteriorly. Sturmdorf sutures are typically used to close the amputated cervical stump.

## *Surgical Outcomes*

All of the Manchester data are retrospective, and the majority of publications are case series. The four retrospective cohort studies comparing Manchester to vaginal hysterectomy showed no difference in anatomic or symptomatic outcomes, with decreased operating time and blood loss in the Manchester group. These studies are limited by poorly defined anatomic outcomes, variable follow-up, and limited reporting. Two of the studies did not mention an apical support procedure with hysterectomy. There were high rates of anterior wall recurrence ranging from 46% to 48%. The most recent cohort reported no difference in prolapse symptom cure (69% vs 74%). Reoperations for recurrent prolapse were low (2%-4%) in the Manchester group, but two studies reported pessary retreatment in 3%-4%. Several additional procedures were required to evaluate and treat abnormal cervical cytology and menstrual disorders that may be due to the Sturmdorf sutures causing cervical stenosis and menstrual issues. Despite good success rates, Kalogirou concluded, “that the Manchester procedure has a limited place in modern gynecology….”

# Sacrospinous Ligament Fixation

Sacrospinous ligament fixation was first described in 1951 and has become one of the most popular and widely utilized apical support procedures through the work of Nichols and Randall. The majority of sacrospinous fixations are performed unilaterally using the right sacrospinous ligament (**FIG. 30.10**), but bilateral suspensions have also been described with native tissue and mesh repairs. The ligament can be approached through the posterior or anterior vaginal wall. The optimal approach depends on the nature of the defect requiring correction. For posterior predominant prolapse with apical descent, the posterior vaginal wall is opened, and the rectal pillar is perforated entering the pararectal space laterally (**FIG. 30.11**). For an anterior approach, after an anterior vaginal incision is made, the paravesical space is entered laterally followed by the pararectal space. Finally, an approach via the vaginal cuff may be preferred with predominantly apical defects. Most sacrospinous ligament fixations are extraperitoneal; however, intraperitoneal entry into the enterocele sac is common with the apical approach. No matter what the approach, it is important to understand the anatomy of the ligament to avoid potential injury.

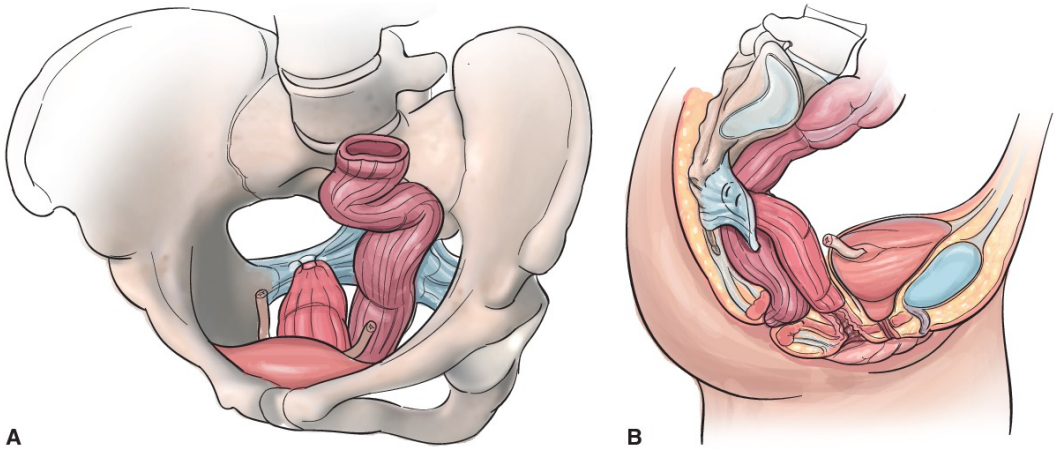


**FIGURE 30.10** Sacrospinous ligament fixation. **A.** Intra-abdominal view of the vaginal cuff transfixed to the right sacrospinous ligament. **B.** Sagittal view of the vaginal cuff

inserting into the middle third of the right sacrospinous ligament.

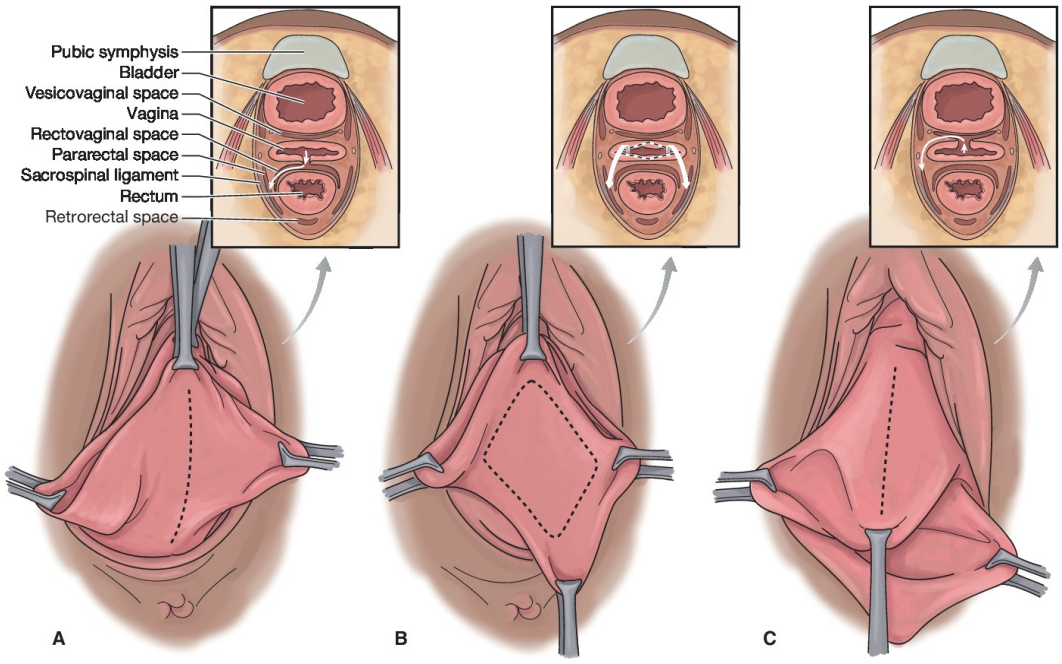


**FIGURE 30.11** Three approaches to sacrospinous ligament fixation. **A.** Posterior approach. After dissection the rectovaginal space, the surgeon perforates the rectal pillar (*arrow*) to enter the pararectal space. **B.** Apical (or cuff) approach. **C.** Anterior approach.

The sacrospinous ligament is a true pelvic ligament running laterally from the ischial spine and attaching medially to the sacrum (**FIG. 30.12**). The coccygeus muscle overlies the sacrospinous ligament with similar attachment sites causing many to refer to this as the coccygeus-sacrospinous ligament (CSSL) complex. The CSSL is surrounded by blood vessels and nerves that must be considered

during surgery (**FIG. 30.13**). The pudendal nerve and vessels pass directly behind the ischial spine. The inferior gluteal vessels, hypogastric venous plexus, and the sciatic nerve and its lumbosacral nerve roots run superior to the ligament. The sciatic nerve and gluteal vessels pass laterally as they enter the greater sciatic foramen. The nerves to the coccygeus and levator ani muscles originate from independent branches of the sacral trunk and lie on the ventral surface of these muscles making it difficult to avoid when placing sacrospinous ligament fixation sutures. An anatomic study evaluated the proximity of the nerves and arteries to sacrospinous sutures. The sutures were placed with a suture-capturing device by an experienced pelvic reconstructive surgeon on eight unembalmed cadavers. The median sacrospinous ligament length was 4.8 cm (range 3.0-6.5 cm), and the two sutures were located 2.0 cm (0.9-3.4 cm) and 2.5 cm (1.2-4.6 cm) from the ischial spine. The nerves to the coccygeus and levator ani muscles were the closest structures (**FIG. 30.14**). Targeting the middle third of the ligament limits the risk of major nerve and vessel injury. Thus, based on these anatomic observations, surgeons should avoid placing sutures through the medial third of the ligament (where the S4 root is consistently located) and should avoid the lateral third and superior margin of the ligament (where the pudendal nerve and vessels run in close proximity).

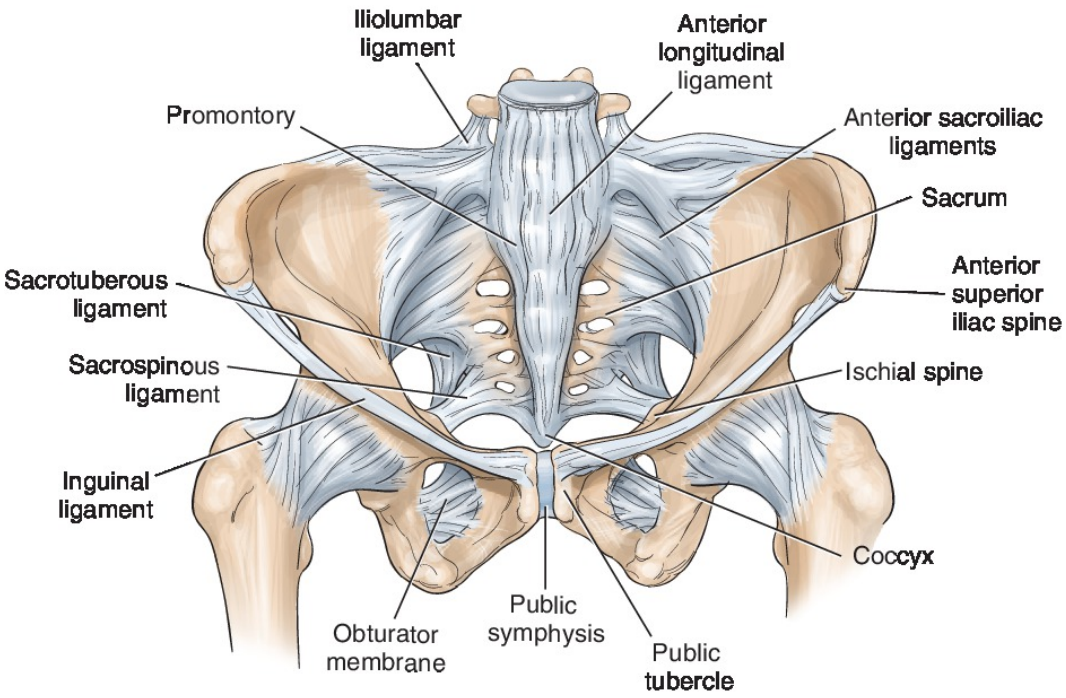


**FIGURE 30.12** Ligaments of the bony pelvis. The sacrospinous ligament extends from the ischial spine to the sacrum. The ligament is wider medially and narrows as it inserts on the ischial spine. The ligament lies within the coccygeus muscle (not shown).

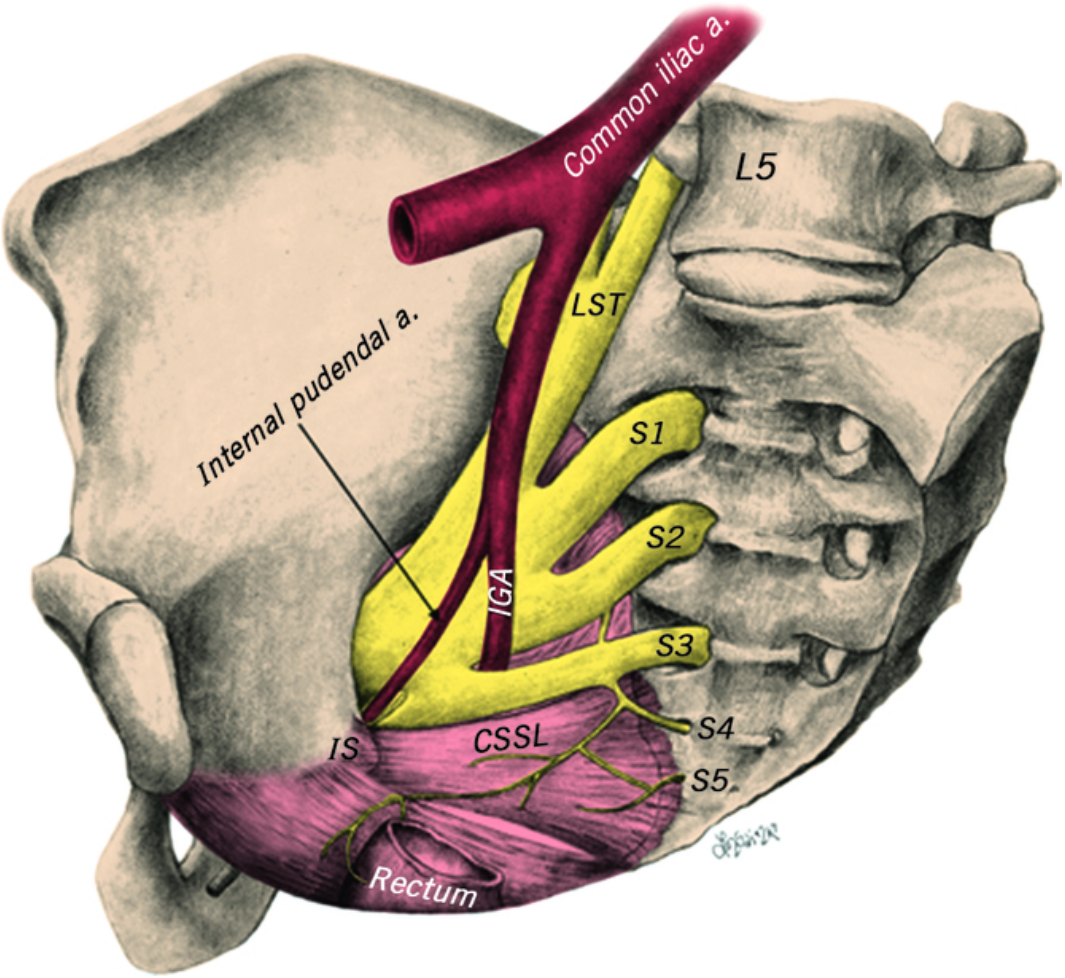


**FIGURE 30.13** The right coccygeus-sacrospinous ligament (CSSL) complex and ischial spine (*IS*) are shown with respect to the course and relationships of the internal pudendal artery, inferior gluteal artery (*IGA*), lumbosacral trunk (*LST*), and sacral nerves (*S1 to S5*). (Reprinted from Roshanravan SM, Wieslander CK, Schaffer JI, et al. Neurovascular anatomy of the sacrospinous ligament region in female cadavers. *Am J*

*Obstet Gynecol*. 2007;197(6):660.e1-660.e6. Copyright © 2007 Elsevier. With permission.)

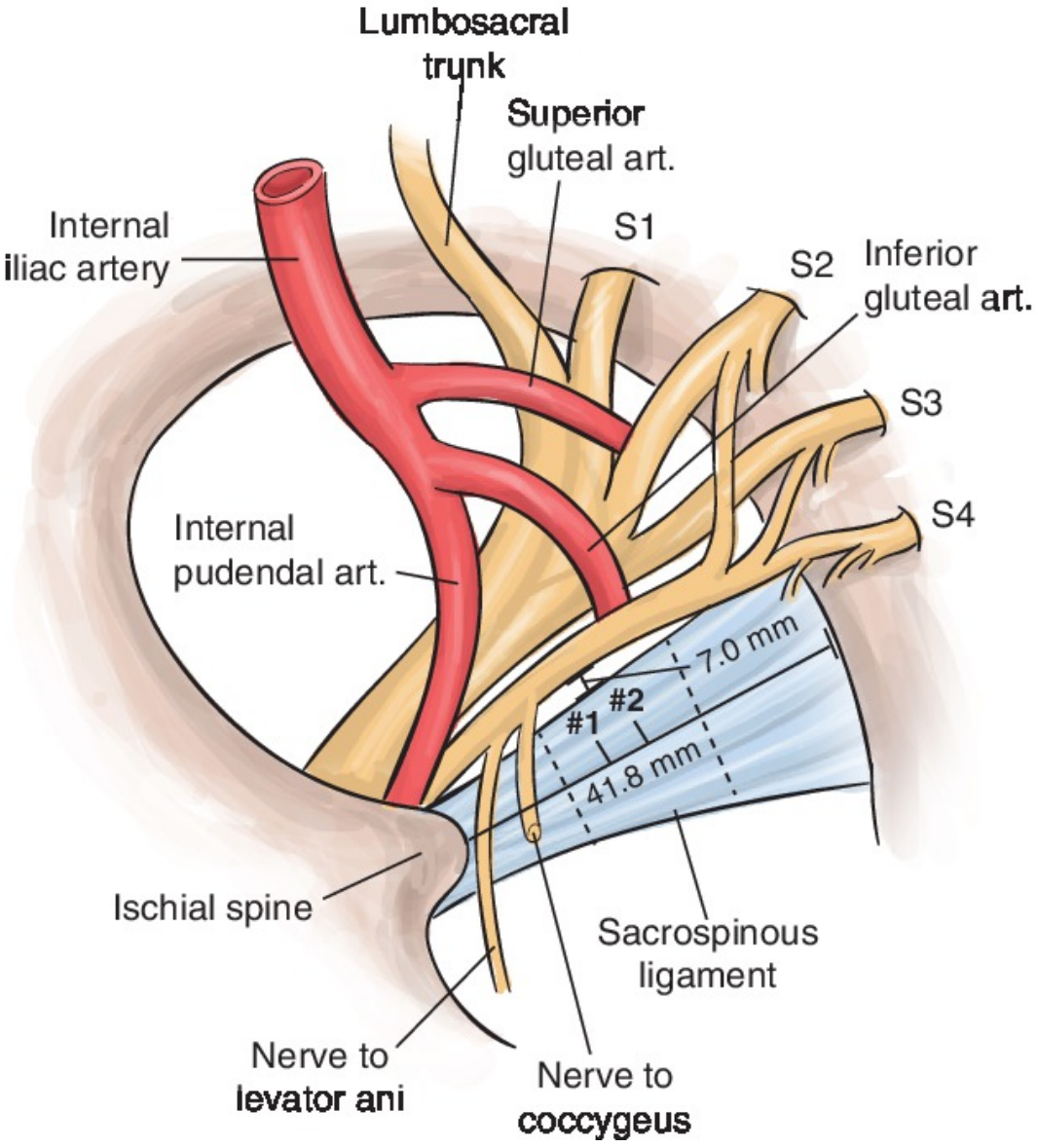


**FIGURE 30.14** The most commonly seen anatomic relationships between nerves and arteries relative to the sacrospinous ligament (divided into thirds) and placed sutures. Numbers represent sample median distance

measured. The position of median suture placement relative to the total length of the ligament is depicted by no. 1 and no. 2. S1-S4, ventral rami of sacral nerves. (Redrawn from illustration by Katrikh AZ, Ettarh R, Kahn MA. Cadaveric nerve and artery proximity to sacrospinous ligament fixation sutures placed by a suture-capturing device. *Obstet Gynecol*. 2017;130:1033-1038. In: Katrikh AZ. Risk to anatomy during sacrospinous fixation. *Obstet Gynecol*. 2017.)

To perform a unilateral right-sided sacrospinous fixation, the most important step is to first identify the planned vaginal apex. This is performed by grasping portions of the proximal anterior, posterior, and lateral vaginal walls with Allis clamps and elevating each of them to the intended suture location on the sacrospinous ligament. The Allis clamp locations are adjusted until each portion of the vagina reaches without tension. In cases of severe apical prolapse with a total vaginal length that is longer than the distance to the sacrospinous ligament, the anterior, posterior, and lateral walls must be shortened to remove excess tissue and provide adequate support. For posthysterectomy vault prolapse, an intervening diamond overlying the vaginal apex is excised and discarded after careful planning. This technique was nicely described and illustrated in the Michigan four-wall sacrospinous suspension for vaginal vault prolapse. If a large enterocele sac is encountered, it can be mobilized and later excised and closed with a purse string suture.

Cuff or apical entry is generally the easiest approach because it does not require perforation of the rectal pillars (necessary when approaching the ligament posteriorly). Cuff entry is still possible even when the initial incision is made along the posterior vaginal wall for posterior predominant prolapse. The sacrospinous dissection is

performed by grasping the vaginal cuff and peritoneal surface with Allis clamps. The space between these surfaces is opened at ~7 o'clock with Metzenbaum scissors sharply or bluntly followed by blunt finger dissection internally toward the ischial spine and sacrospinous ligament. Fingers are swept laterally to medially as the CSSL is cleaned off removing excess tissue. The area is widened to allow placement of the new vaginal apex in direct apposition to the ligament.

Breisky-Navratil retractors help expose the CSSL complex allowing direct visualization (**FIG. 30.15**). Direct visualization of the ligament is necessary when using more traditional suturing devices such as a Miya hook or Deschamps ligature carrier. Alternatively, suturing can be performed by palpation alone (without direct visualization) when using a suture-capturing device. The ischial spine is palpated, and the first suture is placed ~2 cm medial to the ischial spine. One or two additional sutures are placed at ~1-cm increments medial to the initial suture. Care is taken to obtain a good purchase of the ligament staying below the superior margin to reduce the risk of nerve entrapment and bleeding. Sutures placed too inferiorly will be located in the iliococcygeus muscle (rather than in the sacrospinous ligament), resulting in vaginal shortening. The appropriate location of each suture is confirmed by palpation. Delayed absorbable sutures have an advantage over permanent sutures because they can be placed through the full thickness of the vaginal epithelium and tied closing the cuff. These sutures dissolve and may be easier to remove in cases of nerve entrapment and severe persistent buttock pain. When choosing nonabsorbable sutures, a pulley stitch is performed by securing one end of the suture into the fibromuscular layer of the apex excluding the epithelium and tying a half hitch. Traction applied to the free end pulls the vagina onto the ligament where it is fixed in place with a square knot.

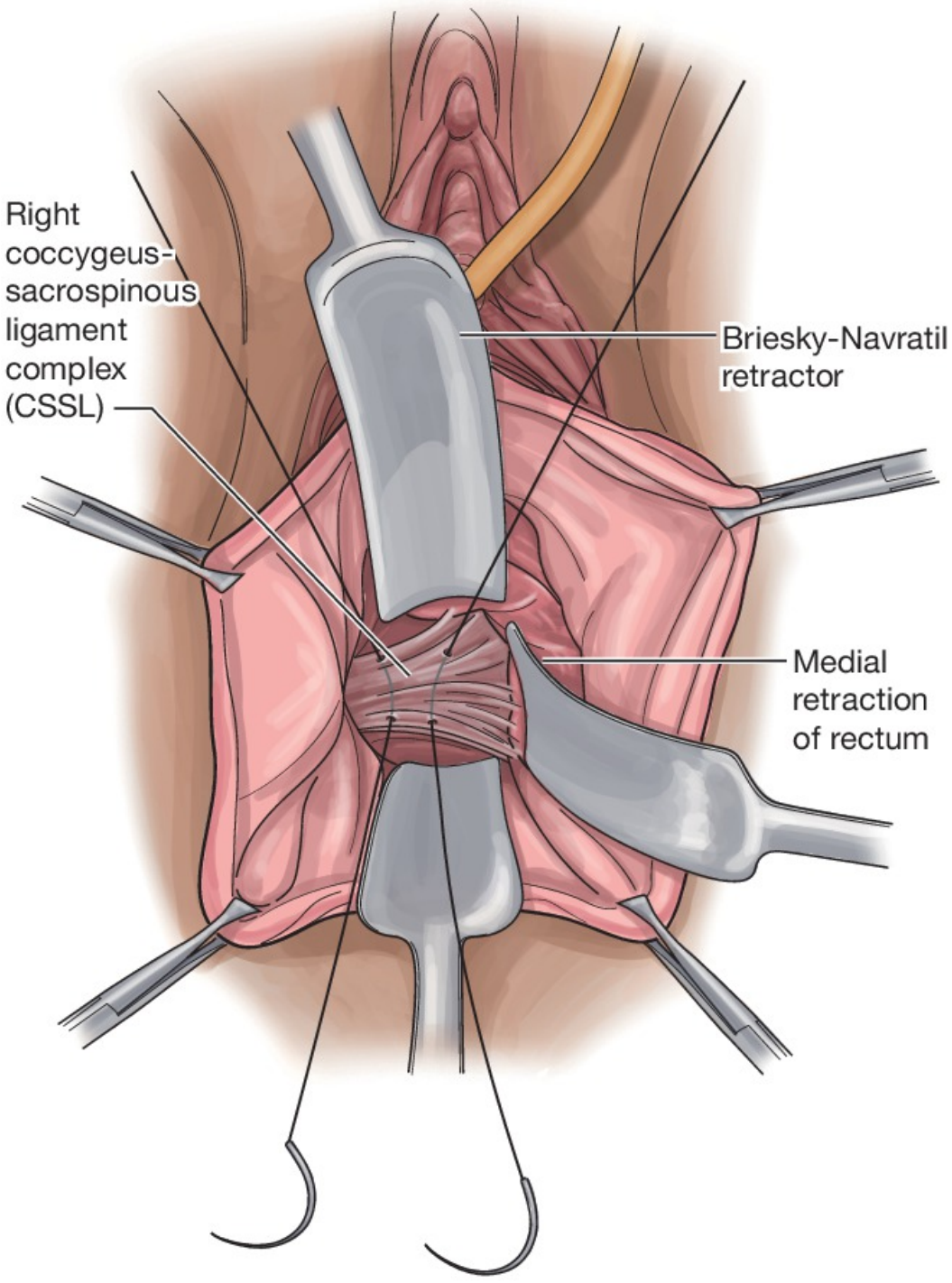
Right coccygeus-sacrospinous ligament complex (CSSL)
Briesky-Navratil retractor
Medial retraction of rectum

**FIGURE 30.15** Two sutures are passed through the sacrospinous ligament.

When anterior colporrhaphy and/or enterocele repair is required, these should be performed prior to tying the sacrospinous sutures. We also recommend starting the proximal posterior colporrhaphy and epithelium closure plus completing any additional cuff closure prior to tying the apical sutures as all of these procedures are more difficult once the cuff sutures are transfixed to the right CSSL. The remainder of the posterior colporrhaphy and perineorrhaphy can then be completed. A rectal examination should always be performed to exclude injury following sacrospinous ligament fixation and posterior colporrhaphy (**BOX 30.3**).

## BOX 30.3 STEPS IN THE PROCEDURE

### Sacrospinous Ligament Fixation

- Following vaginal hysterectomy, palpate the ischial spine and CSSL ligament complex, and identify intended suture location 2 cm medial to the spine.
- Identify the vaginal fixation point that will be suspended to the ligament. This is done by grasping the planned fixation site with Allis clamps. Elevate the site to the intended sacrospinous ligament suture location. Iteratively adjust clamp location to identify the site that will provide adequate support without excess tension.
- For vaginal vault prolapse after hysterectomy, excise excess diamond-shaped vaginal epithelium overlying the enterocele, and dissect enterocele sac bluntly. The enterocele sac can later be excised and closed.
- For an apical approach to the ligament, dissect and open the space between the vaginal cuff and peritoneum at 7 o'clock bluntly and sharply with Metzenbaum scissors. Then perform

blunt finger dissection internally toward the right ischial spine and sacrospinous ligament, sweeping laterally to medially removing excess tissue. Widen the area to permit direct apposition of the vaginal cuff to the ligament.

- Palpate the ischial spine and sacrospinous ligament. Place two to three sutures spaced ~1 cm apart through the middle portion of the ligament. The most lateral suture should be at least 2 cm medial to the ischial spine. Avoid suturing above the superior border of the ligament.
- Secure sacrospinous sutures to the vaginal cuff. Delayed absorbable sutures traverse full-thickness vaginal epithelium and nonabsorbable sutures are only passed through the fibromuscular layer and tied with a pulley stitch.
- Perform anterior colporrhaphy and enterocele repair as indicated.
- Start proximal posterior colporrhaphy and posterior vaginal epithelium closure plus any additional cuff closure.
- Tie and hold apical support sutures elevating the vaginal cuff.
- Cystoscopy confirms ureteral patency and excludes lower urinary tract injury.
- Trim suture tails, close vaginal cuff as indicated, and complete posterior colporrhaphy as indicated followed by rectal examination to exclude injury.

## *Surgical Outcomes*

Similar to uterosacral suspension, most of the evidence for sacrospinous ligament fixation comes from uncontrolled retrospective case series, showing high overall anatomic success rates. Anterior recurrences (3.7%-28.5%) are typically more common than apical recurrences (0.6%-19.0%). Reoperation rates of <9% were found in all but three studies (range 1.3%-37%). A meta-analysis and systematic review by Morgan revealed overall anatomic failure rates (>grade 1) of 28.8% (95% CI, 18.4-36.3) with 7.2%

(95% CI, 4.0-10.4) apical recurrence, 21.3% (95% CI, 17.3%-25.3%) anterior recurrence, and 6.3% (95% CI, 4.2%-8.4%) posterior recurrence. Pooled average failure to relieve prolapse symptoms and failure to provide satisfaction occurred in 10.3% (95% CI, 4.4-16.2) and 13% (95% CI, 7.4-18.6), respectively.

A potential complication of sacrospinous ligament fixation is neuropathic pain, specifically buttock pain. A large multicenter surgical trial found that 12.4% of patients in the sacrospinous group had postoperative buttock pain requiring intervention, with 4.3% persisting 4-6 weeks. While the majority of studies show pain resolution within 6 weeks after surgery without intervention, pain that is severe, persistent, and intractable with radiation down the leg or associated muscle weakness and/or difficulty walking should prompt rapid suture removal preferably within the first few days.

Other severe complications are rare, with the most concerning being rectal injury and hemorrhage from vascular injury. Vascular injuries can be life-threatening and involve the hypogastric venous plexus, pudendal, and inferior gluteal vessels. If bleeding cannot be controlled with sutures, clips, or cautery, then vaginal packing should be inserted and consideration should be given for embolization. The ischiorectal fossa is a potential space for hematoma formation and expansion, which may require packing for hemostasis (and which may lead to the need for delayed incision and drainage in the case of subsequent infection and abscess formation). Rectal lacerations should be repaired with a two-layered closure, while suture injuries simply require recognition and removal of the involved suture(s). Serious complications can be prevented with meticulous dissection and knowledge of the relevant neurologic and vascular anatomy previously discussed.

# Sacrospinous Hysteropexy

Sacrospinous hysteropexy is one of the best studied uterine preservation prolapse surgeries. During this repair, the cervix or uterosacral ligaments are transfixed to the sacrospinous ligament with two or three nonabsorbable or delayed absorbable sutures. An apical approach is often preferred via a transverse incision in the

posterior fornix but can also be accomplished posteriorly or anteriorly. Dissection to the CSSL is performed bluntly and excess tissue removed. Sacrospinous sutures are typically unilateral on the right side in a similar location starting 2 cm medial to the ischial spine. Anterior suture tails are secured to the cervix or uterosacral insertion at the cervix on each side. Posterior suture tails are secured to the distal edge of the posterior fornix incision and held (**FIG. 30.16**). When an anterior colporrhaphy and/or enterocele repair is indicated, this should be performed prior to tying the apical support sutures. If cervical elongation or hypertrophy is present, partial trachelectomy should be considered to improve success rates. The proximal segment of the posterior colporrhaphy and the closure of proximal posterior epithelium should also be started prior to tying the hysteropexy sutures. The remainder of the posterior colporrhaphy is then completed and rectal examination performed to exclude injury (**BOX 30.4**).

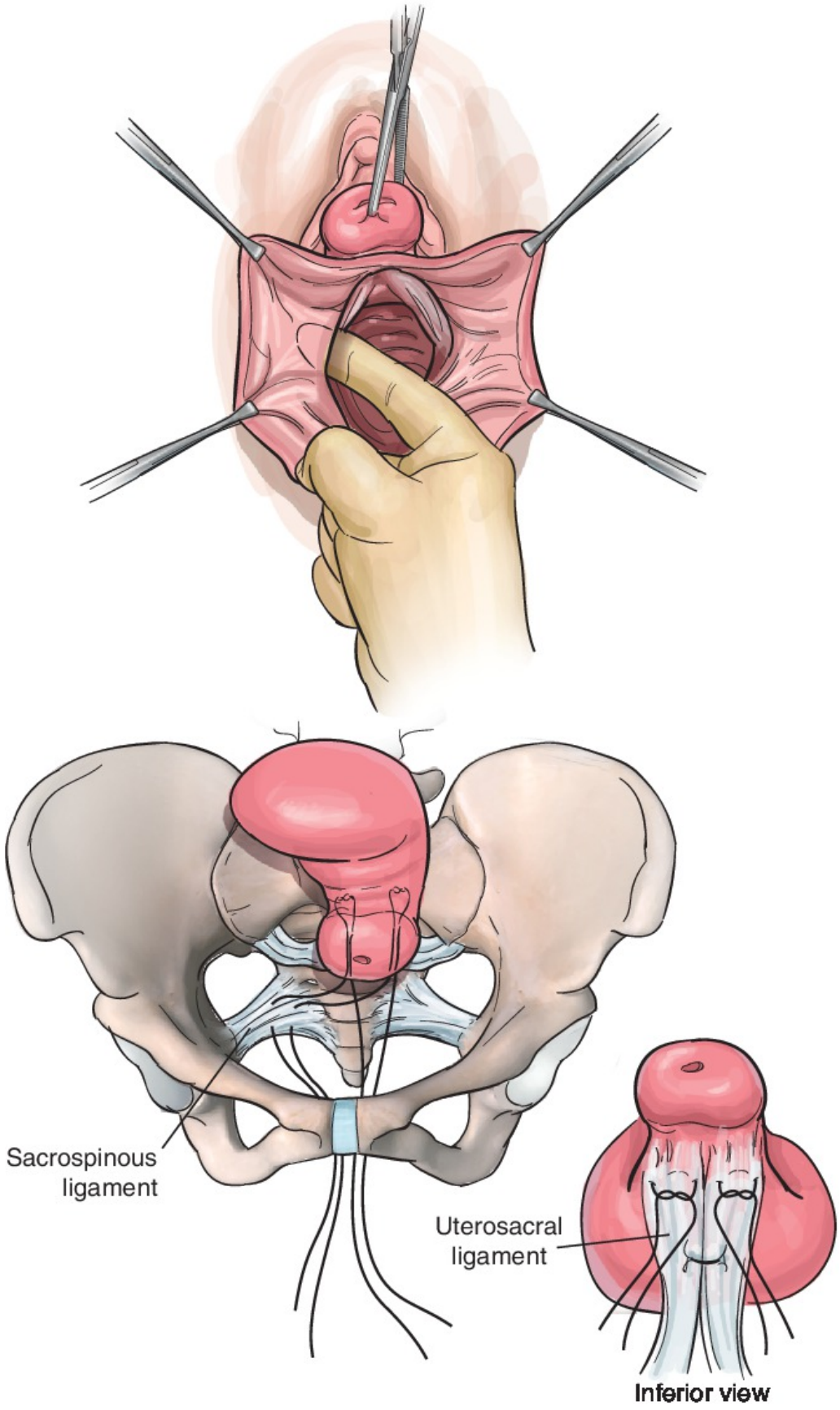
Sacrospinous ligament
Uterosacral ligament
Inferior view

**FIGURE 30.16** Sacrospinous hysteropexy. The posterior fornix is opened and finger dissection performed into the right pararectal space toward the sacrospinous ligament. Two sutures are attached to the middle third of the sacrospinous ligament and each side of the posterior cervix near the uterosacral ligament insertion.

## BOX 30.4 STEPS IN THE PROCEDURE

### Sacrospinous Hysteropexy

- Palpate the ischial spine and CSSL complex, and identify intended suture location 2 cm medial to the spine.
- Grasp the posterior cervix with Allis clamps, and apply traction. Then grasp the proximal posterior vaginal wall bilaterally near the uterosacral ligament insertion using Allis clamps. Elevate the cervix and posterior fornix to the intended sacrospinous ligament suture location. Adjust clamp location to provide adequate support and reach comfortably.
- Make a transverse incision between the Allis clamps in the posterior fornix.
- Dissect and open the space between the distal incision and cervix/cul-de-sac peritoneum at 7 o'clock bluntly and sharply with Metzenbaum scissors. Then perform blunt finger dissection internally toward the right ischial spine and sacrospinous ligament sweeping laterally to medially removing excess tissue. Widen the area to permit direct apposition of the posterior cervix to the ligament.

- Palpate the ischial spine and sacrospinous ligament. Place two to three sutures spaced ~1 cm apart through the middle portion of the ligament. The most lateral suture should be at least 2 cm medial to the ischial spine. Avoid suturing above the superior border of the ligament.
- Secure the sutures anteriorly to the posterior cervix near the insertion site of the uterosacral ligaments bilaterally and posteriorly to the inferior aspect of the posterior fornix incision. Delayed absorbable sutures traverse full-thickness vaginal epithelium and nonabsorbable sutures are only passed through the fibromuscular layer and tied with a pulley stitch.
- Perform anterior colporrhaphy and enterocele repair as indicated.
- Start proximal posterior colporrhaphy and posterior vaginal epithelium closure plus any additional posterior fornix closure.
- Tie and hold apical support sutures elevating the cervix and posterior fornix.
- Cystoscopy confirms ureteral patency and excludes lower urinary tract injury.
- Trim suture tails and complete posterior colporrhaphy as indicated followed by rectal examination to exclude injury.

## *Surgical Outcomes*

Data from two randomized trials and five cohort studies (prospective and retrospective) revealed similar high anatomic apical success (89%) and a low reoperation rate (4.5% vs 3.8%) for sacrospinous hysteropexy compared to hysterectomy and vaginal colpopexy (uterosacral or sacrospinous suspension). However, one of the randomized trials found more apical recurrences (21% vs 3%, $P$ = .03) when hysteropexy was performed for stage 4 prolapse. Both randomized trials showed high rates of anterior recurrences (50%-64%) in each group, but the majority of these were asymptomatic, and reoperation was infrequent. More recently,

Shulten reported 5-year outcomes for the largest randomized trial revealing no differences in anatomical failure, prolapse reoperation (3% vs 7%), quality of life, or sexual function. Of note, there was no increased anterior wall prolapse over time, with low rates of anterior recurrence beyond the hymen (6% vs 8%). Sacrospinous hysteropexy appeared to be associated with a lower rate of anatomic apical failure (1% vs 8%) and with a higher composite success rate (87% vs 76%). Two randomized trials showed no differences in sexual function between sacrospinous hysteropexy and vaginal hysterectomy native tissue repair, with low rates of dyspareunia (5%).

Compared to sacrospinous ligament fixation, similar rates of transient buttock pain have been observed after sacrospinous hysteropexy. Hematoma, bleeding requiring transfusion, and rectal injury may also occur but are rare. Those patients with cervical elongation or hypertrophy should undergo partial trachelectomy to improve success rates based on the results of a prospective two-part study. Lin showed a near 11-fold increased risk of failure following sacrospinous hysteropexy in patients with cervical elongation. Success rates improved to 96%-100% when patients with severe prolapse were excluded and partial trachelectomy was performed.

## Anterior Vaginal Mesh Colpopexy or Hysteropexy

Transvaginal mesh prolapse repairs were introduced in an effort to reduce recurrent prolapse after transvaginal native tissue repairs. However, concerns regarding complications led to a rapid decline in vaginal mesh prolapse repairs. The U.S. Food and Drug Administration (FDA) warnings in 2008 and 2011 resulted in reclassification from class II, moderate-risk devices, to class III, high-risk devices in 2016. Following those actions, the FDA banned transvaginal mesh for prolapse April 16, 2019, stating that the risks outweighed the potential benefits. There are currently no commercially available vaginal mesh products for prolapse repair in the United States. Based on the current situation, this section

contains historical information that is important for understanding how to treat patients who have been implanted with this material.

Vaginal mesh colpopexy or hysteropexy was performed by placing mesh through a vaginal incision and anchoring the mesh into the sacrospinous ligament to provide apical support. To reduce the risk of mesh exposure, an inverted U-shaped incision on the anterior vaginal wall (just proximal to the urethrovesical junction) was preferred to a vertical midline incision. The vesicovaginal space was entered, and dissection continued proximally toward the anterior cervix or cuff. Then lateral sharp and blunt dissection was performed to enter the paravesical space and eventually pararectal space. The ischial spine was palpated, and the CSSL was exposed. Plication of the anterior fibromuscular layer of the vaginal wall was performed (if desired) with an absorbable suture. Various techniques were used to attach the mesh to the CSSL complex and to allow tensioning of the mesh arms. For some mesh products, a suture-capturing device anchored the arms of the mesh into the middle portion of the sacrospinous ligament bilaterally. Some older products anchored the mesh laterally to the arcus tendineus fascia pelvis with arms that were tacked into or traversed the obturator internus muscles bilaterally exiting through groin incisions. Older products alternatively approached the sacrospinous ligament through a buttock incision and traversed the ischiorectal fossa before piercing the CSSL and entering the vagina. In some cases, the mesh was tacked proximally to the anterior cervix or cuff and distally to the fibromuscular layer overlying the bladder near the urethrovesical junction to spread out the mesh. The apical arms were then pulled up providing support without excess tension (**FIG. 30.17**). Cystoscopy confirmed ureteral patency and excluded lower urinary tract injury. Additional posterior colporrhaphy and enterocele repair were performed if necessary. Posterior vaginal mesh repairs were discontinued long before anterior vaginal mesh repairs due to a lack of efficacy compared to native tissue repairs. Some older products contained separate or combined anterior and posterior vaginal mesh repairs with apical support only included with performance of the posterior mesh repair.

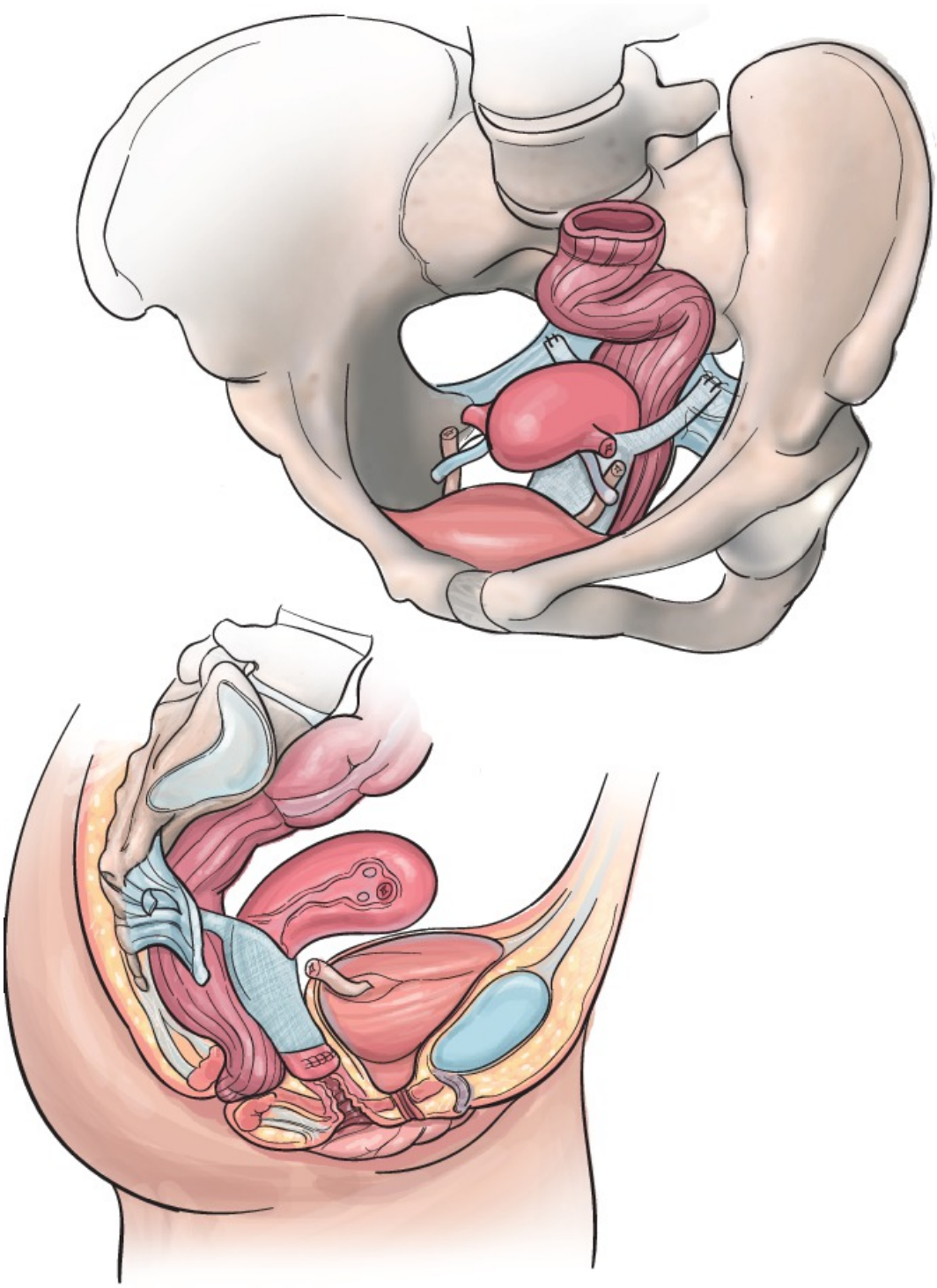

**FIGURE 30.17** Vaginal mesh hysteropexy. **Top.** Intra-abdominal view of the anterior mesh in the vesicovaginal space with arms

that anchor laterally to the sacrospinous ligaments. **Bottom.** Sagittal view, mesh inserted between the bladder and anterior vaginal wall through an inverted U-shaped incision. Mesh is secured to the anterior cervix in the midline and lateral arms attach to each sacrospinous ligament providing apical support.

## *Surgical Outcomes*

Cochrane reviews have demonstrated that vaginal mesh prolapse repairs result in less prolapse symptoms (RR 0.7), fewer anatomic recurrences (RR 0.4), and fewer reoperations for prolapse (RR 0.5) compared to native tissue prolapse repairs. These results are due to the fact that mesh placed in the anterior vaginal wall provides better support and fewer recurrences compared to native tissue. However, overall reoperations were more common (RR 1.4) due to an 8% reoperation rate for mesh complications. A combined analysis of one prospective and four retrospective cohort studies comparing hysteropexy to vaginal hysterectomy with three different first-generation vaginal mesh repairs and one second-generation trocarless mesh repair revealed high anatomic success (96% vs 97%, $P = .50$) with more mesh exposures in the hysterectomy group (5% vs 11%, $P = .02$). Furthermore, early studies using Prolift (Ethicon Women's Health and Urology, Somerville, NJ) revealed a fivefold increased mesh exposure risk with concomitant hysterectomy. Consequently, uterine preservation was preferred when performing a vaginal mesh repair for uterovaginal prolapse in order to minimize mesh risks.

# COMPARATIVE OUTCOMES

Prior sections reviewed comparative outcomes of hysterectomy vs uterine conservation for both uterosacral and sacrospinous ligament suspensions. This section focuses on comparisons among the various native tissue repairs.

## Uterosacral Ligament Suspension vs Sacrospinous Ligament Fixation

The Pelvic Floor Disorders Network conducted the only randomized trial to date comparing uterosacral suspension (*n* = 188) to sacrospinous fixation (*n* = 186) for transvaginal native tissue prolapse surgery. Women with a uterus underwent total vaginal hysterectomy. The groups were also randomized to perioperative pelvic floor muscle training. Composite success was defined as no apical descent more than one-third the vaginal length, no anterior or posterior descent beyond the hymen, no bothersome bulge symptoms, and no retreatment with either pessary or surgery. Success was not significantly different between groups at 2 years (uterosacral 59.2% vs sacrospinous 60.5%, OR 0.9; 95% CI, 0.6-1.5, *P* = .75) or 5 years (38.5% vs 29.7%, adjusted difference −8.8%; 95% CI, −24.2-6.6, respectively). At 5 years, there were also no differences between the individual components that made up the primary composite outcome: bulge symptoms (37.4% vs 41.8%), prolapse (47.5% vs 61.8%), and retreatment (11.9% vs 8.1%). More patients in the sacrospinous group had neuropathic pain requiring intervention (6.9% vs 12.4%) or persisting 4-6 weeks (0.5% vs 4.3%). Ureteral obstruction was recognized intraoperatively in five (3.2%) of uterosacral suspensions with one ureteral injury (0.5%) detected postoperatively, and no ureteral obstructions were seen following sacrospinous fixation. Secondary analysis of condition-specific quality of life including sexual function improved for all subjects with no differences between groups. Rates of dyspareunia were essentially unchanged as baseline dyspareunia decreased from 25% to 16% with 10% *de novo* dyspareunia at 2 years, of which only a few required treatment.

# McCall Culdoplasty vs Uterosacral Ligament Suspension or Sacrospinous Ligament Fixation

There are no randomized trials comparing McCall culdoplasty to either uterosacral suspension or sacrospinous fixation. A retrospective cohort compared patients undergoing vaginal hysterectomy and either modified McCall culdoplasty (*n* = 215) or Shull uterosacral suspension (*n* = 124) with absorbable sutures. At a mean follow-up of over 2 years, there were no differences in anatomic success (79.1% vs 84.7%) or reoperations (1.4% vs 1.6%) between groups. The majority of recurrences occurred in the anterior compartment (13% vs 10.5%) with few apical recurrences (1.4% vs 0.8%). Postoperative prolapse symptoms were infrequent in both groups (6.2% vs 7.9%), and high satisfaction was observed. Similar low rates of ureteral obstruction (2.3%) were detected intraoperatively and treated. Among sexually active patients, dyspareunia was similar between groups with many improved (14.1% vs 15.6%) and limited *de novo* dyspareunia (4.3% vs 5.6%).

Colombo and Milani retrospectively compared patients who underwent vaginal hysterectomy with either sacrospinous fixation (*n* = 62) or modified McCall culdoplasty (*n* = 62). During 4-9 years of follow-up, there were no significant differences in apical (8% vs 5%) or overall anatomic (27% vs 15%) recurrences between groups. Anterior recurrences were more common after sacrospinous fixation (21% vs 6%, *P* = .04; OR 4.1; 95% CI, 1.3-14.2), although no differences were seen in the previously discussed randomized trial comparing uterosacral suspension and sacrospinous fixation. Another group prospectively measured vaginal length and sexual function using the Pelvic Organ Prolapse/Urinary Incontinence Sexual Function Questionnaire-12 (PISQ-12) in patients undergoing McCall culdoplasty (*n* = 29) compared to sacrospinous fixation (*n* = 29). They found similar baseline vaginal length (8.9 cm) and shortened postoperative vaginal length in both groups with a greater decrease in the McCall culdoplasty group (7.2 vs 8.2 cm, *P* < .001) that did not equate to differences in postoperative sexual function.

# *Hysteropexy Procedures vs Hysterectomy Using Database/Registry*

A retrospective cohort study using data from the California Office of Statewide Health Planning and Development compared reoperation after prolapse surgeries with ($n$ = 43 340) and without ($n$ = 51 491) hysterectomy. They controlled for many baseline differences between the two groups, including the fact that mesh was more commonly used without hysterectomy (17.6% vs 9.6%). Prolapse reoperation was lower after surgery that included hysterectomy (3% vs 4.4%, RR 0.67, $P$ < .001). When considering only index surgeries with apical suspension procedures (hysterectomy 21 487 and hysteropexy 18 839), hysterectomy was associated with fewer repeat surgeries for apical (1.9% vs 3.3% $P$ < .001), anterior (1.3% vs 2.2% $P$ < .001), and posterior (1.3% vs 2.2% $P$ < .001) prolapse. Perioperative complications associated with hysterectomy included transfusion (2.5% vs 1.5%), infection/sepsis (0.9% vs 0.4%), readmission for infection (0.7% vs 0.3%), and urologic injury/fistula (0.9% vs 0.6%).

Data from the Danish National Patient Registry were used to compare outcomes after Manchester procedure ($n$ = 2786), vaginal hysterectomy ($n$ = 4045), and sacrospinous hysteropexy ($n$ = 416), performed from 2010 to 2016. They reported many baseline differences between groups including older age and more severe apical/posterior prolapse for vaginal hysterectomy compared to Manchester subjects. Sacrospinous hysteropexy was associated with higher reoperation risk compared to either Manchester (aHR 5.0) or vaginal hysterectomy (aHR 3.3). Vaginal hysterectomy was associated with slightly increased reoperation risk compared to Manchester (aHR 1.5). Five-year reoperations were highest for sacrospinous hysteropexy (30%) followed by vaginal hysterectomy (11%) and Manchester (7%). Unfortunately, it is unclear what apical support procedure was performed with vaginal hysterectomy.

Both the California and Danish studies have important limitations, including the potential for selection bias. A multicenter noninferiority randomized trial is underway in the Netherlands comparing the

modified Manchester procedure with sacrospinous hysteropexy for primary uterovaginal prolapse. The study is limited to patients with milder uterine prolapse (POP-Q point D less than or equal to −1 cm) indicating concerns that the Manchester procedure is not appropriate for more severe apical prolapse.

## Vaginal Hysteropexy Comparative Trials

Data are limited to guide surgeons regarding the best hysteropexy procedure. There are no randomized trials comparing different types of vaginal hysteropexy procedures. Sacrospinous hysteropexy is supported by the highest level of evidence and appears to offer outcomes similar to those of native tissue repairs with hysterectomy. Vaginal mesh hysteropexy is purported to prevent anterior vaginal wall recurrences but is no longer commercially available.

Two recent retrospective cohort studies from a single institution evaluated outcomes following vaginal uterosacral hysteropexy and sacrospinous hysteropexy. The first study considered outcomes for 130 hysteropexy procedures (89 sacrospinous and 41 uterosacral). Comparing the hysteropexy patients to 260 matched controls who underwent suspension plus hysterectomy, hysteropexy was associated with fewer overall adverse events (10.5% vs 29%, *P* = .02, aOR 4.0, 95% CI, 1.5-11.0). Within the group of 130 hysteropexy procedures, uterosacral hysteropexy and sacrospinous hysteropexy were associated with similar rates of adverse events, although sacrospinous hysteropexy had shorter operative time (89 vs 104 minutes, *P* = .04). Among the subset of 30 sacrospinous hysteropexy and 17 uterosacral hysteropexy subjects with at least 2-year follow-up, there were no differences in composite recurrence (26.7% vs 23.5%, *P* = 1.0) or retreatment (6.7% vs 0, *P* = .53). In addition, a recent multicenter retrospective cohort study compared sacrospinous hysteropexy (*n* = 147) vs uterosacral hysteropexy (*n* = 114). Both groups experienced low rates of intraoperative adverse events (7.3%), although the investigators observed more ureteral

kinking in the uterosacral group (7% vs 1.4%, *P* = .02). They found no differences in prolapse recurrence at 1 year.

## CHOICE OF REPAIR

Given the wide variety of surgical approaches to treat pelvic organ prolapse and the lack of high-quality data to guide therapy, a number of opinions have been proposed regarding best practices. Some surgeons believe that a primary transvaginal native tissue prolapse repair should be favored over sacrocolpopexy. However, other surgeons recommend sacrocolpopexy for primary surgery, especially for patients felt to be at higher risk of recurrent prolapse. Decisions regarding the choice of primary uterovaginal prolapse surgery should be based on patient's goals, surgeon expertise, and a detailed discussion between the surgeon and patient-weighing risks, benefits, and alternatives during informed consent. Patient's goals should be elicited before surgery and often include resolution of prolapse bulging and discomfort symptoms but may also include desire for uterine preservation, avoiding mesh complications, and/or having the most durable primary repair. Often, the patient's goals conflict. Prioritizing goals may help identify the optimal surgical approach for that individual patient.

## KEY POINTS

- Performance of an apical support procedure is a key component toward restoring anatomy and function, which is the ultimate goal of reconstructive pelvic surgery.
- Based on published studies, native tissue repairs are preferable to transvaginal mesh repairs for transvaginal treatment of apical pelvic organ prolapse. Vaginal mesh repair kits are no longer commercially available.
- McCall culdoplasty, uterosacral ligament suspension, and sacrospinous ligament fixation are all reasonable options for transvaginal apical suspension at the time of vaginal

hysterectomy. Anatomic and success rates are relatively similar, and risks are generally low with each procedure having specific risks that require expertise to prevent and treat associated complications.

- For appropriately selected patients, hysteropexy is reasonable for those desiring uterine preservation.
- Level I evidence comparing sacrospinous ligament fixation to uterosacral ligament suspension reveals no difference in overall composite outcomes as well as individual components including anatomic support (overall and compartment specific), symptom resolution, and retreatment (pessary or surgery).
- Growing evidence favors the use of delayed absorbable sutures for transvaginal apical support to avoid complications such as suture erosion and recurrent granulation tissue.

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# CHAPTER 31

# SACROCOLPOPEXY

Anthony G. Visco

**Introduction: Loss of Apical Support**
**Preoperative Considerations**
**Coexisting Urinary Incontinence**
**Surgical Technique**
**Sacrocolpopexy by Open Technique/Laparotomy**
Dissection of the Vagina
Dissection of the Presacral Space
Mesh Attachment
**Minimally Invasive Approaches**
Technique Steps for Laparoscopic Sacrocolpopexy
Technique Steps for Robotic Sacrocolpopexy
Concomitant Procedures
**Surgical Variations**
Sacrohysteropexy
Sacrocolpoperineopexy
**Postoperative Considerations**
Outcomes
Complications

# INTRODUCTION: LOSS OF APICAL SUPPORT

The evaluation and diagnosis of apical pelvic organ prolapse (POP), either uterovaginal or vaginal vault prolapse, can be challenging secondary to coexisting anterior and posterior vaginal support defects. For patients with prolapse, it is critical that apical support defects be addressed and surgically corrected in order to reduce the risk of recurrent prolapse and reoperation. While native tissue vaginal procedures are reasonable options, they have consistently been associated with a higher likelihood of recurrent POP. Conversely, mesh sacrocolpopexy is associated with a lower risk of awareness of prolapse, recurrent prolapse on examination, repeat surgery for prolapse, postoperative stress incontinence, and dyspareunia compared to both native tissue and mesh augmented vaginal prolapse procedures. This chapter reviews the preoperative evaluation, indications, and surgical techniques of sacrocolpopexy, focusing on minimally invasive laparoscopic and robotic-assisted options, relevant anatomy, clinical outcomes, and associated complications.

The use of mesh to perform an abdominal sacrocolpopexy (ASC) was originally described in 1962, using a suspensory bridge of synthetic or biologic graft material to resuspend the vagina and/or cervix to the anterior longitudinal ligament that runs in the midline along the anterior surface of the sacrum. Mesh sacrocolpopexy has a robust literature to support its durability and is frequently referred to as the gold standard for POP surgery. The concept of augmenting a POP repair with synthetic mesh is common in the gynecological literature. Similar to the use of graft-augmented repairs in the hernia literature that are associated with a 50% reduction in the risk of recurrent hernia, the use of mesh reduces the risk of recurrent POP but is associated with a risk of mesh exposure or erosion and reoperation.

While sacrohysteropexy is an option, most surgical repairs for uterovaginal prolapse currently include a total or supracervical hysterectomy in addition to apical support. Historically, the

sacrocolpopexy was reserved as treatment for posthysterectomy POP. There were no effective techniques for apical prolapse until the mid-20th century, and because most gynecologists were not trained in them, they resorted to a hysterectomy (which alone does nothing to improve apical support). Consequently, recurrent POP was usually a phenomenon limited to posthysterectomy patients. Such women were typically referred to subspecialists trained in apical repairs for vaginal vault prolapse, such as the sacrocolpopexy.

Beginning in the 1990s, surgeons began using the sacrocolpopexy as primary treatment for patients with advanced stage uterovaginal prolapse, rather than limiting its use to the treatment for recurrent vaginal vault prolapse. This paradigm shift in treatment philosophy paralleled an expansion of minimally invasive laparoscopic approaches, with and without robotic assistance in gynecologic surgery. Together these factors have allowed sacrocolpopexy, a highly effective and now minimally invasive option, to be offered to patients who previously would have had to accept a longer recovery and higher complications associated with open sacrocolpopexy. Many specialized centers are routinely performing this as an outpatient, same-day discharge procedure and have shown this to be safe and well-tolerated.

# PREOPERATIVE CONSIDERATIONS

The goals of any surgical repair for POP should be to alleviate the patient's symptoms of POP (including bladder, sexual, and bowel dysfunction) and to surgically resupport prolapsed tissue and organs. This is best achieved by reestablishing the normal anatomic relationships and normal orientation of the pelvic organs, primarily the bladder, vagina, cervix (if present), and rectum. When present, prolapse of the distal anterior and posterior vaginal walls and a widened genital hiatus should also be corrected. Care should be taken to avoid under or overcorrection, which can lead to persistent symptoms of POP or new problems such as abnormal bladder or sexual function. The precise anatomical surgical goals are determined by considering both symptoms attributed to the abnormal anatomy and the anatomic support defects present.

## COEXISTING URINARY INCONTINENCE

Some patients with apical prolapse also have symptoms of stress urinary incontinence. Surgical treatment for stress incontinence may be performed at the same time as sacrocolpopexy. In addition, some patients with severe prolapse do not report stress incontinence but may be at risk of developing stress incontinence postoperatively after surgical correction of prolapse. This phenomenon called “occult stress incontinence” is believed to be due to correction of urethral “kinking” caused by the prolapse and has been studied in randomized trials and is discussed in detail in Chapter 33.

The informed consent process should include a discussion of the risk of postoperative urinary incontinence and the risks inherent with the use of surgical mesh. The American Urogynecologic Society has a patient educational “toolkit” to help guide the discussion. It is prudent to consider the patient’s functional goals, severity of POP, risk factors for recurrence, and risk factors for surgical complications. With increasing surgical experience, the vast majority of sacrocolpopexy procedures can safely be performed with a minimally invasive approach (laparoscopic with or without robotic assistance). In selected situations, even repeat sacrocolpopexy may be performed safely as an outpatient via a robotic approach at specialized centers. This procedure is more complicated than a primary repair, as this typically requires removal of the previous sacrocolpopexy mesh and complete replacement using a new mesh.

## SURGICAL TECHNIQUE

Sacrocolpopexy can be performed via laparotomy or laparoscopy with or without robotic assistance. Regardless of approach, the fundamental principle of a sacrocolpopexy entails the suspension of the vagina to the anterior longitudinal ligament of the sacrum using graft material to bridge the distance. The following sections describe the general procedural steps, regardless of route, followed by specific points such as port placement and positioning

considerations for a laparoscopic or robotic approach (see **BOX 31.1**).

## BOX 31.1 STEPS IN THE PROCEDURE

### Sacrocolpopexy

- The patient is positioned in Allen stirrups and safely secured for Trendelenburg positioning using a standardized method. Antibiotic and thromboprophylaxis are initiated. Surgical safety checklist is completed.
- The bladder is drained with an indwelling Foley catheter.
- A supracervical or total hysterectomy is performed if patient has uterovaginal prolapse.
- A vaginal probe, such as rounded end-to-end anastomosis (EEA) sizer, is placed.

### Anterior and Posterior Vaginal Dissection

- The vesicovaginal space is opened, and the bladder is dissected off the anterior vaginal wall.
- The rectovaginal septum is opened, and the rectum is separated from the vaginal wall.

### Presacral Dissection

- The presacral space is entered through a midline longitudinal peritoneal incision beginning near the sacral promontory and extending the incision inferiorly.
- The middle sacral vessels are identified and coagulated if necessary.
- The anterior longitudinal ligament should be clearly identified.
- The peritoneal incision is then extended into the cul-de-sac, keeping the right ureter in view.

## Anterior and Posterior Mesh Attachment

Typically, a Y-shaped polypropylene mesh is trimmed to the appropriate length and attached to the anterior and posterior vagina using either monofilament permanent polypropylene sutures or monofilament delayed absorbable sutures. The sacrocolpopexy mesh is attached with several sutures anteriorly and separately with several sutures posteriorly.

## Sacral Mesh Attachment

- The appropriate mesh tension is determined by a vaginal examination at the bedside.
- The tail of the mesh is attached to the sacrum using two to three permanent sutures, such as Gore-Tex (Gore, Flagstaff, AZ) or polypropylene, with care to avoid injury of the middle sacral vessels.
- As the sutures are tied down, the vagina should be elevated using a vaginal probe to reduce the tension on the mesh and facilitate the suturing of the mesh to the sacrum.

## Peritoneal Closure

- The peritoneum is closed over the graft along its entire length using delayed absorbable suture.

## Cystoscopy

- Cystoscopy is performed to evaluate ureteral patency and to exclude lower urinary tract injury.

Preoperative bowel preparation while common in the past is not indicated for sacrocolpopexy via laparotomy or minimally invasive approaches. Antibiotic prophylaxis with a second-generation cephalosporin or substitute is recommended. Thromboembolic prophylaxis is also recommended in the form of sequential compression stockings or injectable anticoagulants depending on the patient's preoperative risk status.

# SACROCOLPOPEXY BY OPEN TECHNIQUE/LAPAROTOMY

The patient should be placed in the low lithotomy position using Allen (or similar) stirrups to provide access to the perineum during the surgical procedure. A transverse Pfannenstiel incision provides adequate exposure to the pelvis and sacrum and is associated with improved healing and cosmetic results compared to a vertical incision. A uterine manipulator, end-to-end anastomosis (EEA) sizer, or sponge stick can be placed into the vagina to allow for apical manipulation (see **FIG. 31.1**). A Foley catheter is placed for bladder drainage. After entry into the peritoneal cavity, the bowel is gently packed into the upper abdomen. The ureters and internal iliac vessels are identified. A supracervical (or total hysterectomy) is typically performed in patients with uterovaginal prolapse unless a sacrohysteropexy is planned.

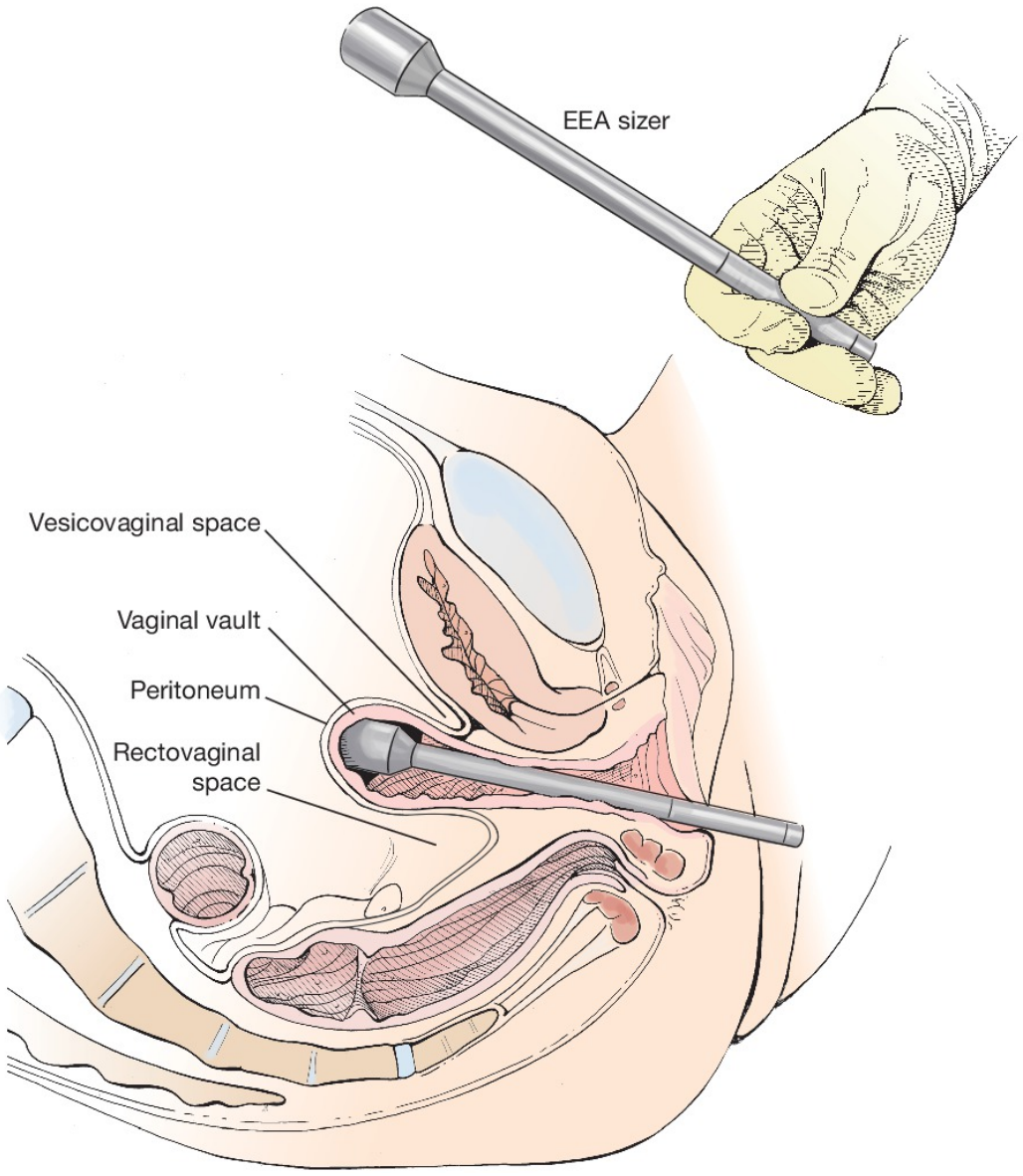



**FIGURE 31.1** Elevation of the vaginal vault using an end-to-end anastomosis (EEA) sizer. (Modified from Cundiff GW, Azziz R, Bristow RE. *Te Linde's Atlas of Gynecologic Surgery*. 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2014. Figure 36.2a.)

# Dissection of the Vagina

Some recommend starting the procedure with the dissection at the sacrum; however, we generally start with dissection of the vagina. The EEA is used to elevate the apex of the vagina, and the bladder is carefully dissected off the anterior vaginal wall for ~4-8 cm. The Foley bulb can be manipulated to determine the edges of the bladder and can be helpful to avoid a cystotomy, as the bladder is often adherent to the vaginal cuff after hysterectomy. Sometimes the bladder is adherent over the apex and to the posterior vagina in patients with vaginal vault prolapse.

The posterior vagina is exposed by entering the rectovaginal space and continuing the dissection distally and laterally in a “U” shape manner to reflect the rectum and peritoneal attachments. We purposefully leave the peritoneum on the posterior vaginal wall in the midline to help prevent weakening of the posterior vagina and to help reduce the risk of vaginotomy and subsequent mesh exposure. The posterior vagina should be dissected for 6-8 cm and can be extended to the perineal body in cases of perineal descent. Distal defects are easily corrected with a concomitant posterior repair performed vaginally.

# Dissection of the Presacral Space

The aortic and vena caval bifurcations are proximal to the sacral promontory. Identification of other key anatomical landmarks, including the ureter and left common iliac vein, is critical to avoid injury to these structures. The presacral space is developed by incising the peritoneum overlying the sacrum just distal to the sacral promontory. This peritoneum is grasped with forceps and incised using electrocoagulation and extended inferiorly. It is most efficient to dissect posterior to the overlying fat pad as there is often an areolar space between the posterior surface of the fat pad and the anterior longitudinal ligament. Avoidance of the middle sacral vessels and the presacral venous plexus is critical as bleeding in this space can be challenging to control with vessels retracting below the surface of the sacrum. The middle sacral vessels can be avoided or coagulated (see **FIG. 31.2**).

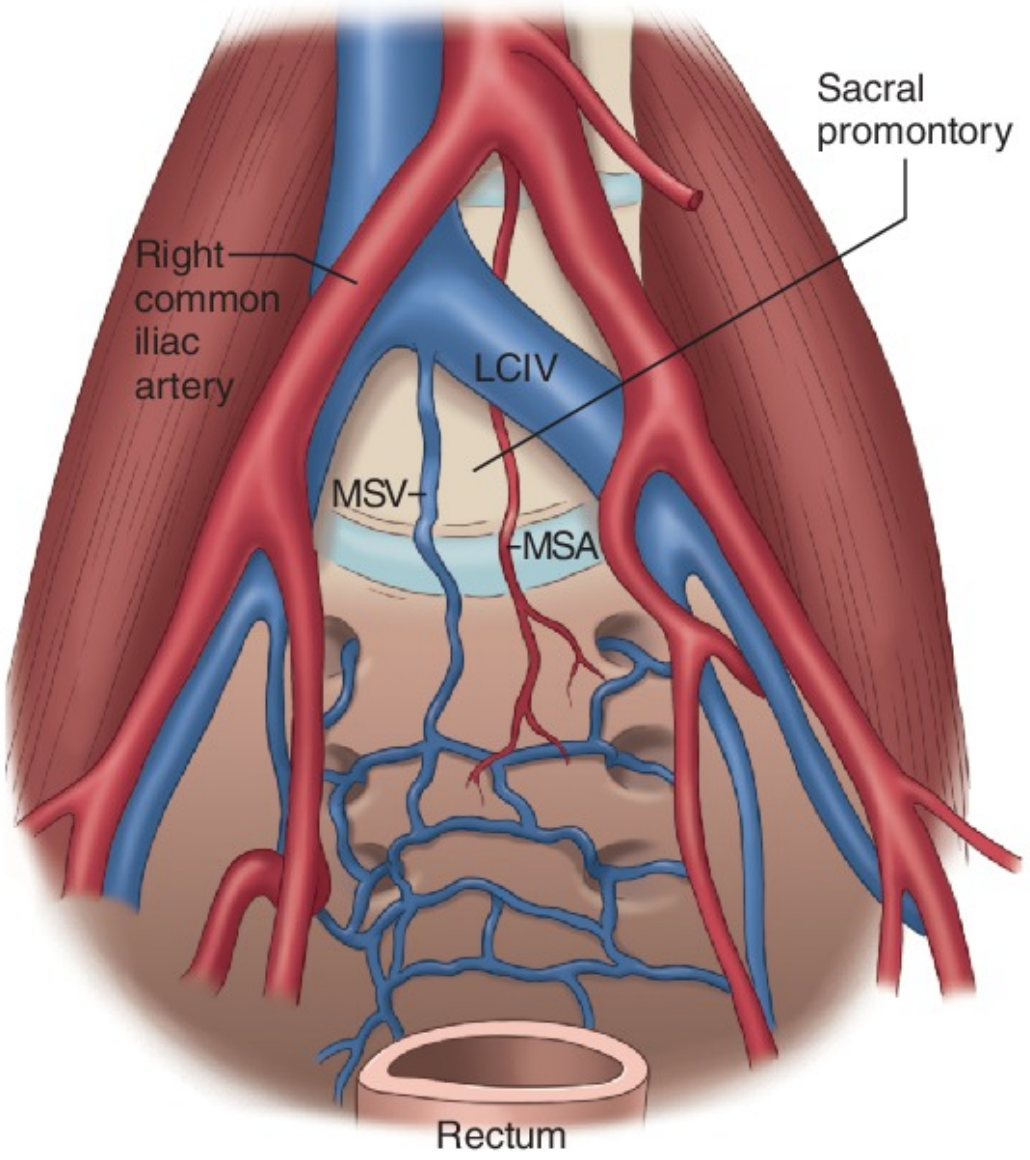



**FIGURE 31.2** Vascular anatomy of the presacral space. The bifurcation of iliac veins lies posterior and caudal to the arteries. The left common iliac vein is vulnerable to injury if not properly identified and avoided during sacral dissection or mesh attachment during sacrocolpopexy. The precise anatomy of the presacral can be quite variable but includes

the middle sacral artery (MSA), middle sacral vein (MSV), and sacral venous plexus. (Reprinted from Wieslander CK, Rahn DD, McIntire DD, et al. Vascular anatomy of the presacral space in unembalmed female cadavers. *Am J Obstet Gynecol.* 2006;195(6):1736-1741. Copyright © 2006 Elsevier, with permission.)

Since the sacral promontory corresponds to the L5/S1 disc space, placing sutures precisely at the promontory is generally discouraged (see **FIG. 31.3**). Sutures are placed distal to the sacral promontory at the level of the S1 or S2 vertebral body. After the fixation point has been exposed, the inferior edge of the sacral peritoneal incision is then extended inferiorly in the midline for a few cm and then follows a curvilinear path between the rectosigmoid and the right ureter. The dissection ultimately connects to the posterior peritoneal dissection. Care to avoid injury to the sigmoid or creating the incision too close to the right ureter is critical.

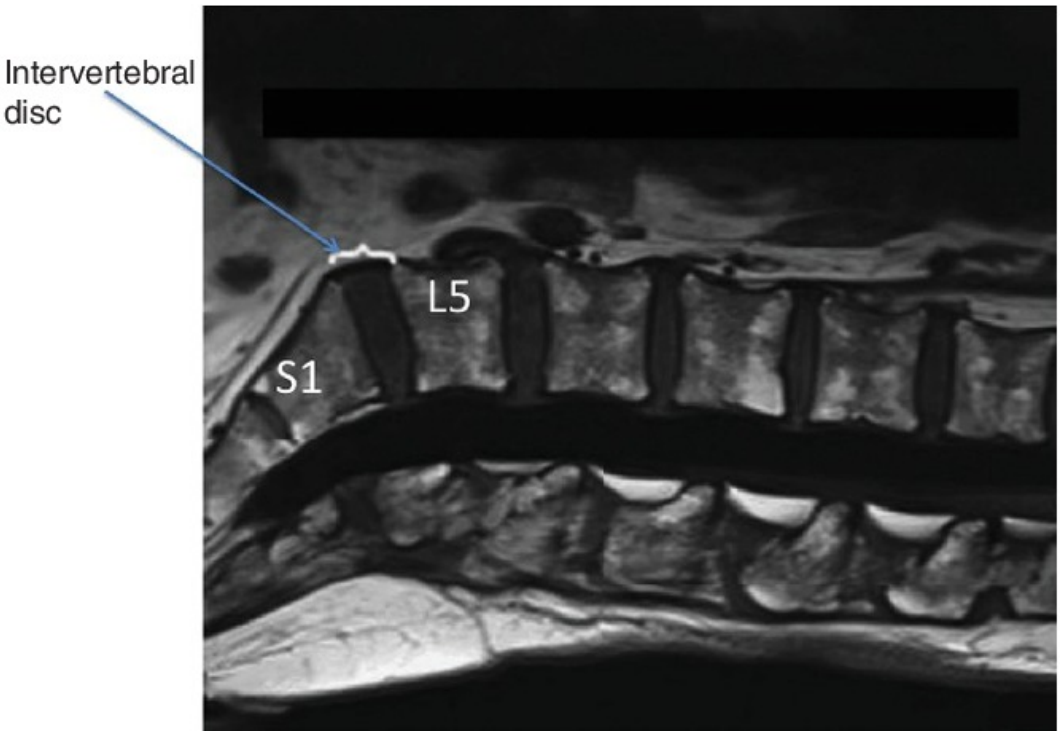


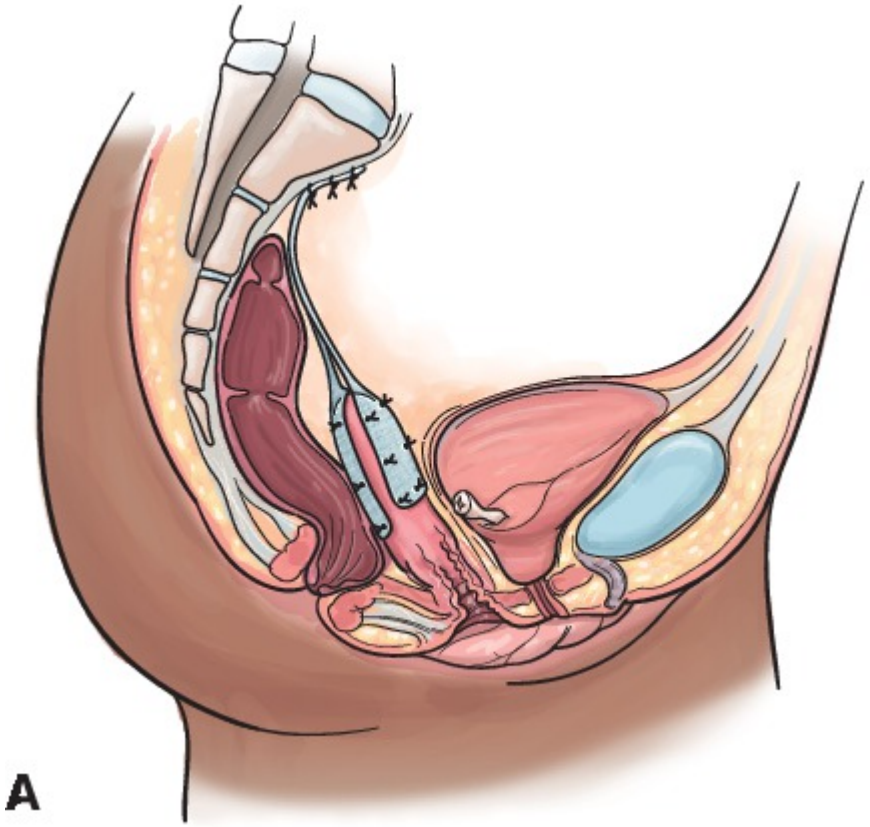

**FIGURE 31.3** Midsagittal MRI image shows the L5/S1 vertebral disc located at the sacral promontory. (Reproduced with permission from Berek JS, Tarnay CM. *Operative Techniques in Gynecologic Surgery: Urogynecology*. Wolters Kluwer; 2019. Figure 4.4.)

## Mesh Attachment

Over the last two decades, a variety of graft materials have been reported for sacrocolpopexy, including biologic and synthetic materials. Large-pore, lightweight polypropylene mesh is currently the preferred graft material given its monofilament and macroporous characteristics. We use a prefabricated Y-shaped polypropylene mesh and cut the anterior and posterior arms to the appropriate length. Using a vaginal probe to elevate the vagina, the mesh is

attached to the anterior vaginal wall using approximately five to eight sutures of monofilament permanent suture materials. A similar procedure is used to attach the posterior arm of mesh to the posterior vaginal wall. Some surgeons use monofilament delayed absorbable sutures to attach the mesh to the vagina.

The vagina is next elevated with the vaginal probe, and the appropriate amount of tension on the mesh is determined. The mesh is then trimmed to the appropriate length and attached to the anterior longitudinal ligament of the sacrum with two to four sutures of permanent suture material. We typically use CV-2 Gore-Tex on a THX-22 needle to attach the mesh to the sacrum (see **FIG. 31.4A**). If a sacrocolpopexy is performed for uterovaginal prolapse immediately after a supracervical hysterectomy, the mesh can be attached in a similar fashion and attached to the vagina and to the cervix (see **FIG. 31.4B**).



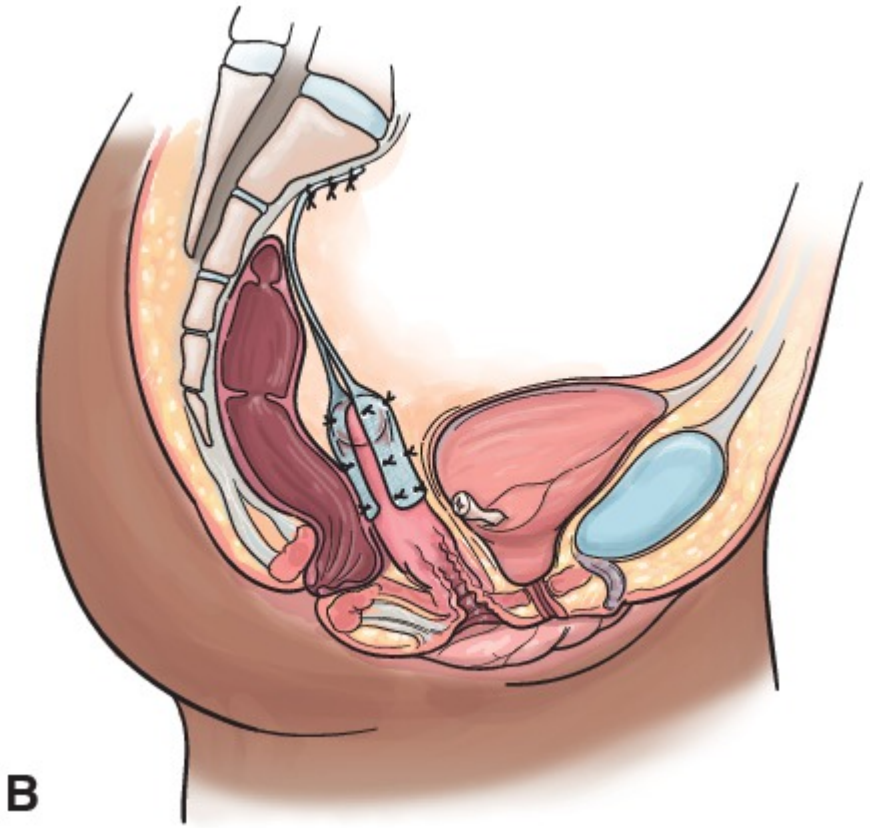



**FIGURE 31.4** Sacrocolpopexy using a Y-shaped mesh to the anterior longitudinal ligament of the sacrum distal to the sacral promontory. **(A)** shows attachment of the mesh to anterior and posterior vaginal walls as treatment of vaginal vault prolapse. **(B)** shows attachment of the mesh to the anterior and posterior vaginal walls and cervix in a patient with uterovaginal prolapse after supracervical hysterectomy.

The exposed mesh is retroperitonealized to reduce the risk of small bowel obstruction due to adhesions from the bowel to exposed mesh

or secondary to an internal hernia with a loop of small intestines becoming trapped under the mesh bridge. The peritoneum can be reapproximated over the mesh using running 2-0 Vicryl suture.

Lumbosacral osteomyelitis and discitis are rare but potentially devastating complications of sacrocolpopexy. It is recommended to place the sutures distal to the promontory as these can enter the intervertebral disc and introduce infection leading to osteomyelitis and discitis.

A cystoscopy is indicated to confirm bilateral ureteral patency and to confirm the absence of a cystotomy.

Any remaining anterior or posterior defects can be addressed with a vaginal anterior or posterior colporrhaphy, respectively. A suburethral mesh sling can be performed as treatment of stress urinary incontinence.

# MINIMALLY INVASIVE APPROACHES

Careful patient positioning is particularly important for both laparoscopic and robotic-assisted sacrocolpopexy as these place the patient in the Trendelenburg position. A variety of products are available to safely secure patients in Trendelenburg, including all-in-one solutions. These are designed to prevent patients from sliding and to reduce the risk of nerve injuries. Per guidelines of the Association of periOperative Registered Nurses, the patient's arms and hands are usually tucked at the side of the patient with the wrist in a neutral, thumbs up position using an integrated foam positioner. Adjustable Allen or similar stirrups allow access to the perineum and leg repositioning during the procedure.

We do not use of shoulder blocks as these have been associated with brachial plexus nerve injuries. We use the minimum amount of Trendelenburg needed to achieve adequate bowel mobilization into the upper abdomen and to achieve adequate pelvic visualization.

Most of the time we make our initial entry at the umbilicus using a Verres needle or open technique. The umbilicus is generally at the L3-L4 level and directly over the aortic bifurcation. The umbilicus is usually caudal to the aortic bifurcation in obese patients. In obese patients, the surgeon may direct the Verres needle or laparoscopic

trocar in a more perpendicular angle to reduce the risk of tracking through the subcutaneous tissues.

After initial entry is confirmed, the surgeon performs a careful survey of anatomy, other pelvic or abdominal pathology or adhesions and identifies the location of the inferior epigastric vessels. Knowledge of abdominal wall anatomy is important to avoid injury to the inferior epigastric artery and vein, branches of the external iliac, which run cephalad along the lateral edges of the rectus muscles. Hemorrhage resulting from injury to these vessels can be challenging as they anastomose with the superior epigastric vessels. Depending on the location of injury, these vessels often require suture ligation both superior and inferior to the site of injury.

## Technique Steps for Laparoscopic Sacrocolpopexy

Laparoscopic sacrocolpopexy can be performed with a variety of port placement configurations. In addition to an umbilical 5-mm trocar for the laparoscopic camera, we typically place a 5/12-mm disposable trocar on the side where the surgeon will be performing extracorporeal knot tying. This 5/12-mm trocar should be placed lateral to the inferior epigastric vessels, ~3 cm medial and cephalad to the anterior superior iliac spine. This trocar allows for the easy passage of a variety of needles. An additional 5-mm port is placed on the same side to allow the primary surgeon to comfortably control the needle for suturing and suture manipulation. A 5-mm trocar is placed symmetrically in the contralateral lower quadrant. For any trocar ≥10 mm, the fascial incision is closed with 0-Vicryl at the end of the procedure to minimize the risk of port-site hernia. One or two additional 5-mm trocars are placed to help with retraction, dissection, as well as suture and mesh management (**FIG. 31.5**). We recommend the use of trocars that have external ribs or threads to help prevent the trocar from slipping.

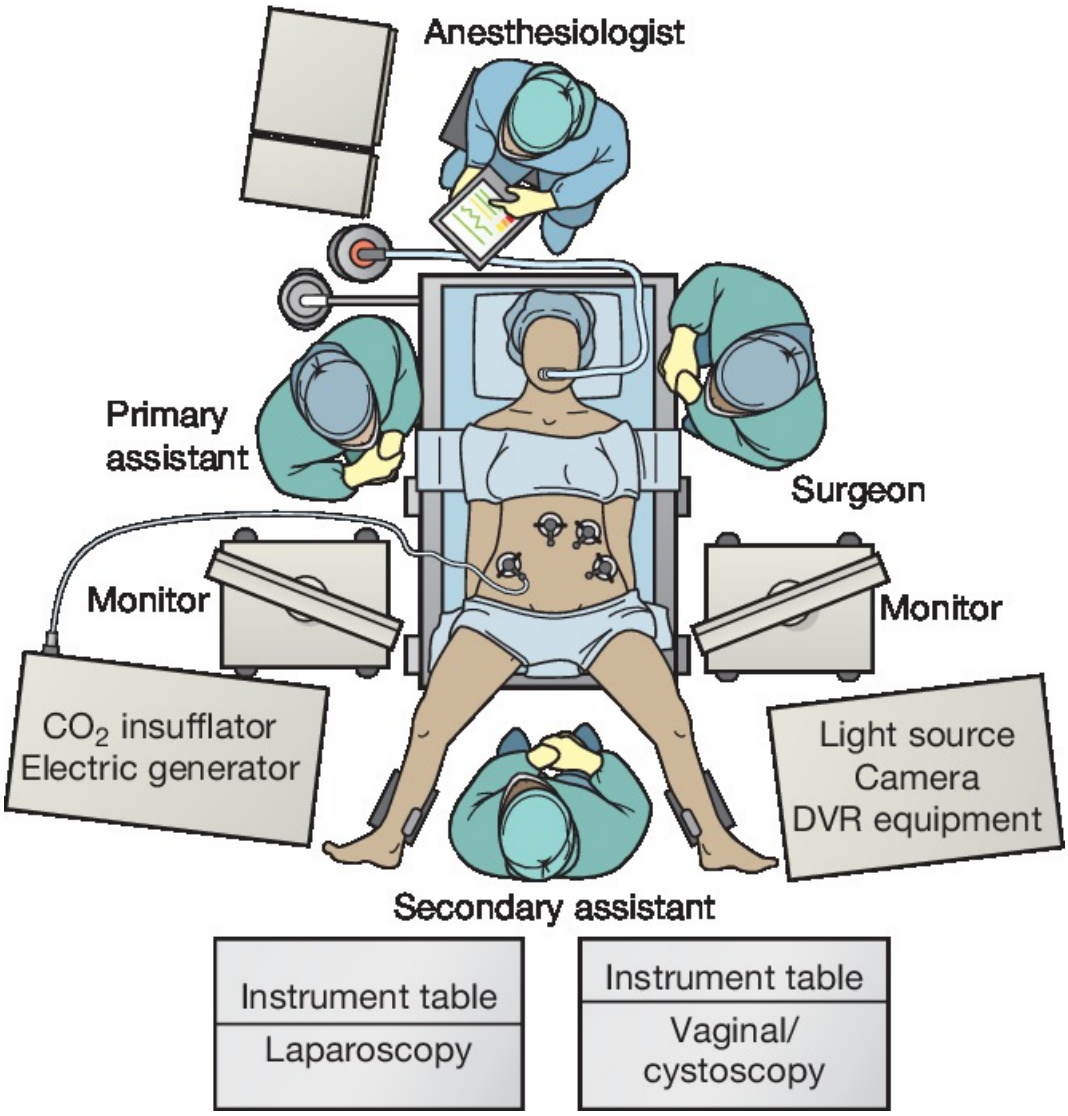



**FIGURE 31.5** Operating room setup for a laparoscopic sacrocolpopexy. This is similar to other gynecologic laparoscopic surgeries with appropriate placement of monitors, electrosurgical generators, and suctioning. Typically, a 5/12-mm trocar and an additional 5-mm trocar are placed on the same side to facilitate suturing.

The dissection and attachment of the mesh is similar to that described using the open sacrocolpopexy technique. Most surgeons performing laparoscopic sacrocolpopexy elect extracorporeal knot-tying, tying each suture before placement of the next. We prefer using a closed-ended knot pusher, but this is merely a preference. Others prefer an open-ended knot pusher or avoid knot tying. Some surgeons use a barbed suture to attach the mesh to the vagina. However, the use of barbed delayed absorbable suture has been associated with small bowel obstruction when used to attach the mesh to the vagina and to close the posterior parietal peritoneum.

The sacral end of the mesh is attached to the anterior longitudinal ligament of the sacrum using permanent sutures. Some surgeons prefer the use of an automated tacking device.

## Technique Steps for Robotic Sacrocolpopexy

We have been routinely performing robotic sacrocolpopexy since 2006. We perform a robotic sacrocolpopexy following the same general steps and principles of an open and laparoscopic sacrocolpopexy. The da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) is currently the only widely used robotic surgical system in the United States. The da Vinci Xi is the latest multiarm system and has three components: the patient cart (operative robot), surgeon console, and vision cart. The Xi system provides significant advantages that include easier docking due to the rotating boom and the ability of use a robotically controlled 8-mm camera in any of the ports. For robotic sacrocolpopexy, we prefer left side docking to allow easy access to the perineum for uterine and vaginal positioning (see **FIG. 31.6**).

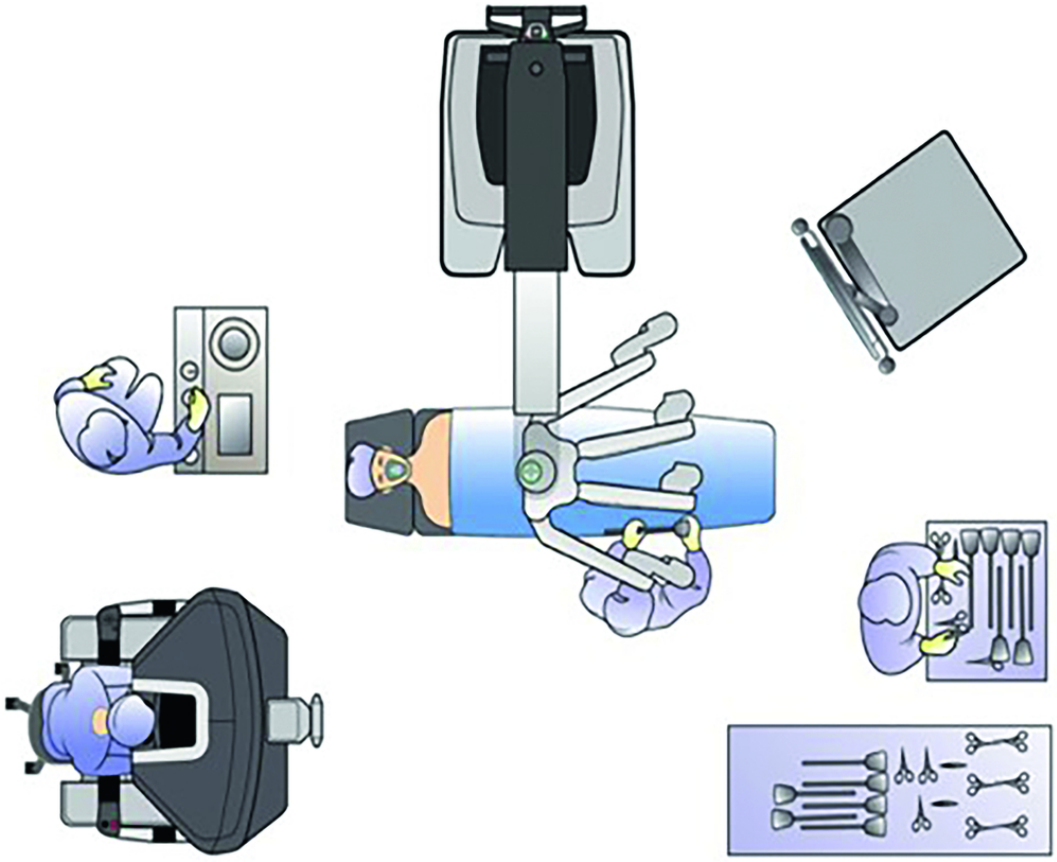


**FIGURE 31.6** Operating room setup for a robotic sacrocolpopexy showing left side docking. (Courtesy of Intuitive Surgical, Inc.)

Trendelenburg positioning can be varied during laparoscopic procedures but cannot be easily changed during a robotic procedure unless the da Vinci Xi is paired with a specialized Trumpf Operating Room table. This pairing allows repositioning during the procedure by insuring that the robotic arms and the OR table move in a synchronized manner.

The robotic sacrocolpopexy does differ in a few distinct manners from the laparoscopic approach. First, port placement is different. We place 4 robotic 8-mm trocars and an 8-mm assistant port using a "W" or arc configuration (see **FIG. 31.7**). Robotic trocars should be placed at least 10 cm apart to minimize internal and external collisions of the robotic arms. Two robotic ports are placed 10-11 cm

lateral and ~30° inferior to the umbilicus. A third robotic port is placed in the left upper quadrant 10-11 cm from the left lower quadrant trocar and primarily used for robotic retraction. This provides the robotic console surgeon a high degree of autonomy.

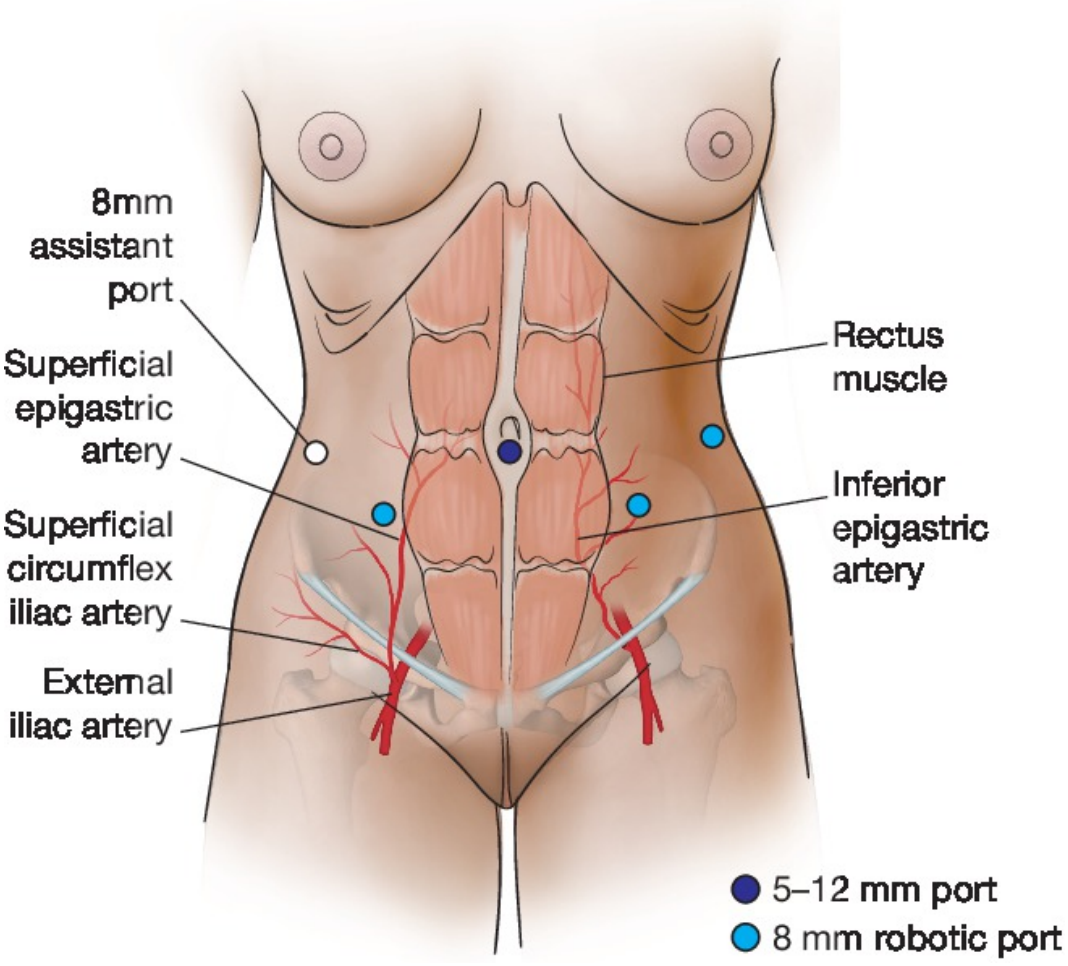



**FIGURE 31.7** Port placement using a typical "W" configuration for a robotic sacrocolpopexy. (Modified from Berek JS, Falcone T, Uy-Kroh MJ, et al. *Operative Techniques in Gynecologic Surgery: Gynecology*. 1st ed. Wolters Kluwer; 2017. Tech Fig 5.1.)

We use an 8-mm right lateral assistant port. This obviates the need to close the fascia, reduces postoperative discomfort, and is still an adequate size to pass SH and THX-22 needles. In our original experience with robotic sacrocolpopexy, we placed a 12-mm lateral accessory trocar and closed the fascia with a needle fascial closure device. Despite placing the 12-mm trocar at least 3 cm cephalad and lateral to the anterior superior iliac spines to avoid nerve entrapment, a few of our patients experienced ilioinguinal or iliohypogastric nerve entrapment requiring subsequent suture release. Use of an 8-mm lateral accessory trocar has completely avoided this, and the reduction in postoperative pain has allowed us to routinely perform robotic sacrocolpopexy as an outpatient (same-day discharge) procedure.

After the trocars have been placed and the patient has been positioned in ~25° of Trendelenburg, the bowel is gently moved into the upper abdomen to allow visualization of the pelvis and sacrum. These steps alone usually achieve adequate bowel mobilization. In the rare instances that the bowel remains in the pelvis or at the pelvic brim, we place a Raytec in the abdomen through the accessory port and open it carefully to create a parachutelike covering that helps keep the bowel positioned in the upper abdomen. Additional attention is needed to be certain that the Raytec is removed at the end of the surgery. This procedure can be difficult and requires advanced laparoscopic skills but allows the patient to have a minimally invasive approach.

Prior to docking, the surgeon should confirm that the robotic “remote center” is close to the parietal peritoneum. When using the da Vinci Xi robot, switching the camera orientation between 30° up and 30° down is so easy that we no longer use the 0° camera. This improves our OR set up efficiency. We primarily use the 30° down for the hysterectomy and sacrocolpopexy, especially during the sacral dissection. Compared to the 0° camera, the 30° down camera allows for improved visualization distal to the promontory (see **FIG. 31.8A** and **B**). The camera oriented at 30° up is helpful during port placement, during dissection of the posterior vaginal wall, and during attachment of the posterior vaginal mesh.

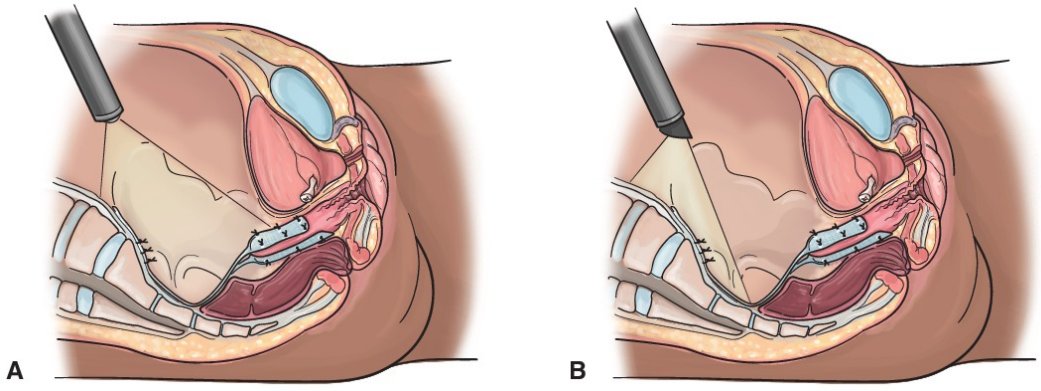



**FIGURE 31.8** **A.** 0° scope can present challenges to optimally view the presacral space. **B.** 30° down scope enables better visualization of the sacrum distal to the promontory as the sacrum angles sharply down.

A robotic sacrocolpopexy using Y-shaped polypropylene mesh is shown in VIDEO 31.1. The steps are as follows:

1. **Hysterectomy**: If the patient has uterovaginal prolapse, we typically perform a supracervical hysterectomy. Compared to total hysterectomy, supracervical hysterectomy is preferred to minimize risk of mesh erosion or exposure. We coagulate the endocervical canal with monopolar and bipolar coagulation. If a concomitant total hysterectomy is indicated, we reinforce the vaginal cuff with a double-layered closure using a delayed absorbable suture. Regardless of hysterectomy status, if fallopian tubes are present, it is our practice to recommend bilateral salpingectomy as a cancer risk–reducing procedure.
2. **Anterior Dissection:** Dissection of the bladder off the anterior vaginal wall is facilitated by placing a rounded EEA sizer (31-33 mm) in the vagina, elevating the vaginal apex (see FIG. 31.9). If the plane between the bladder and vagina is obscure, we find gentle manipulation of the Foley bulb helps to define the plane

between bladder and vaginal wall, avoiding a cystotomy or vaginotomy.

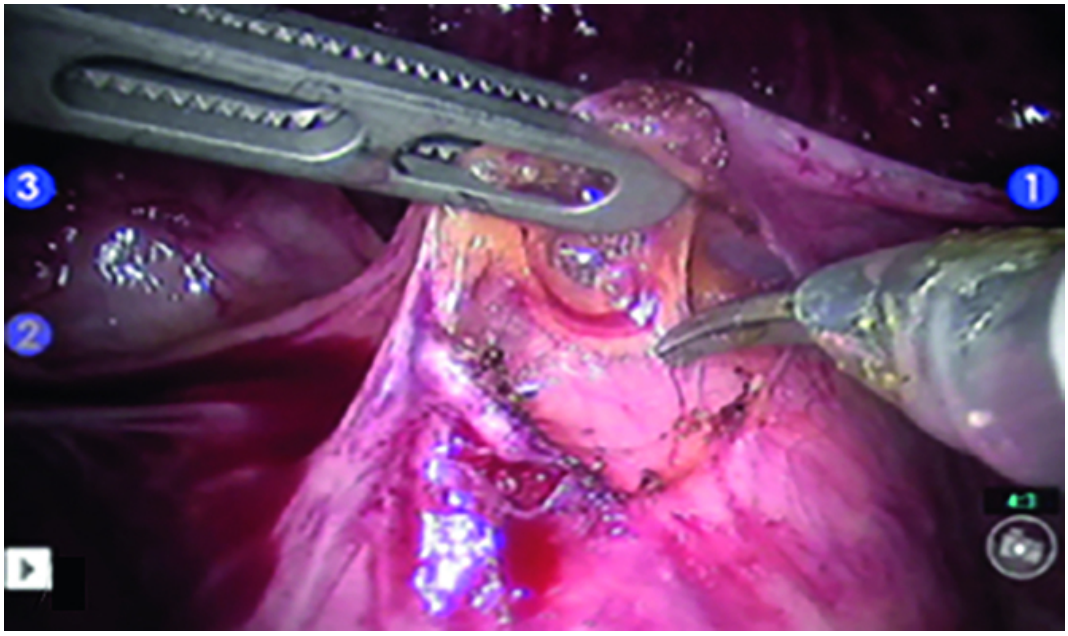



**FIGURE 31.9** Dissection of the bladder off the anterior vaginal wall with an EEA sizer in the vagina.

3. **Posterior Dissection:** With the EEA sizer still in the vagina, we dissect the rectum off the posterior vaginal wall by making a U-shaped incision in the posterior peritoneum. The rectal attachment is often identified by a yellowish line created by perirectal fat. We create wide peritoneal edges to facilitate closure of the peritoneum over the mesh, which is intended to reduce the risk of small bowel obstruction. A 30° up scope is often helpful to improve visualization (see **FIG. 31.10**).

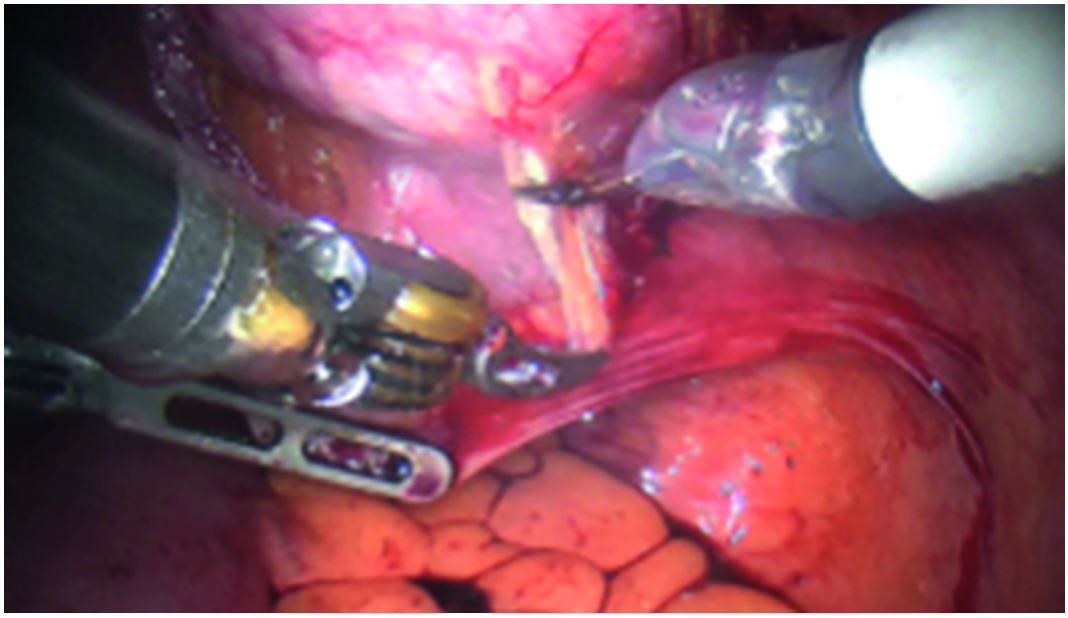


**FIGURE 31.10** Dissection of the rectovaginal septum with posterior deflection of the rectum to expose the posterior vaginal wall. Use of a 30° up scope can be helpful to maximize visualization.

4. **Presacral Dissection:** The camera is oriented 30° down to facilitate visualization during the presacral dissection, identification of the anterior longitudinal ligament and presacral vasculature and anatomy. One should maintain the camera's horizontal orientation to avoid becoming disoriented. We tent the peritoneum during the initial incision to avoid injuring presacral vessels and enter the areolar plane underlying the presacral fat pad (see **FIG. 31.11**). The peritoneal incision is extended into the pelvis to meet the posterior peritoneal incision.

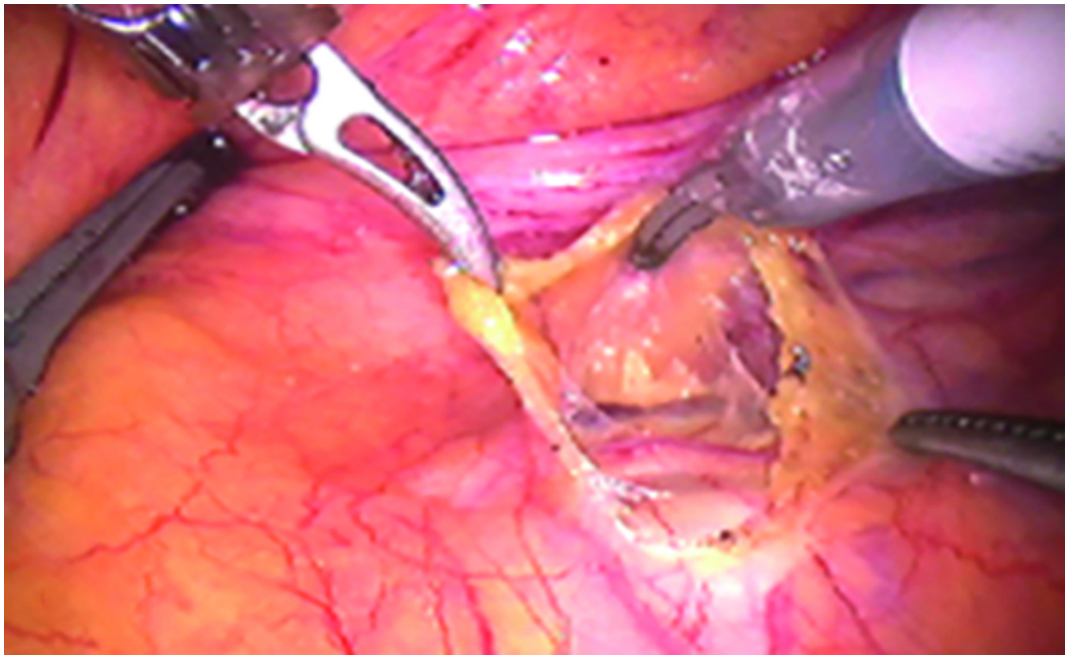


**FIGURE 31.11** Dissection of the presacral space to identify and clear the anterior longitudinal ligament of the sacrum for mesh attachment while avoiding injury to the middle sacral vessels and presacral venous plexus.

5. **Anterior and Posterior Mesh Attachment:** We prefer using a Y-shape, polypropylene mesh. We attach the mesh to the anterior and posterior vagina using monofilament permanent polypropylene suture. Some surgeons use monofilament delayed absorbable suture and other utilize a barbed suture to decrease the need for tie surgical knots. We have developed an efficient way to tie intracorporeal knots. Efficient knot tying is particularly important given the number of sutures required for a complete sacrocolpopexy (**VIDEO 31.1**). We attach the anterior mesh arm with 6-10 sutures and a similar number to secure the posterior mesh arm. Our standard approach is to first attach the distal anterior mesh, then work our way toward the vaginal apex (see **FIG. 31.12A**). We suture the mesh to the cervix if present. We then place the proximal posterior mesh

sutures and work our way distally along the posterior vaginal wall. A 30° scope oriented in the up position can help facilitate attachment of the mesh to the posterior vaginal wall (see **FIG. 31.12B**).

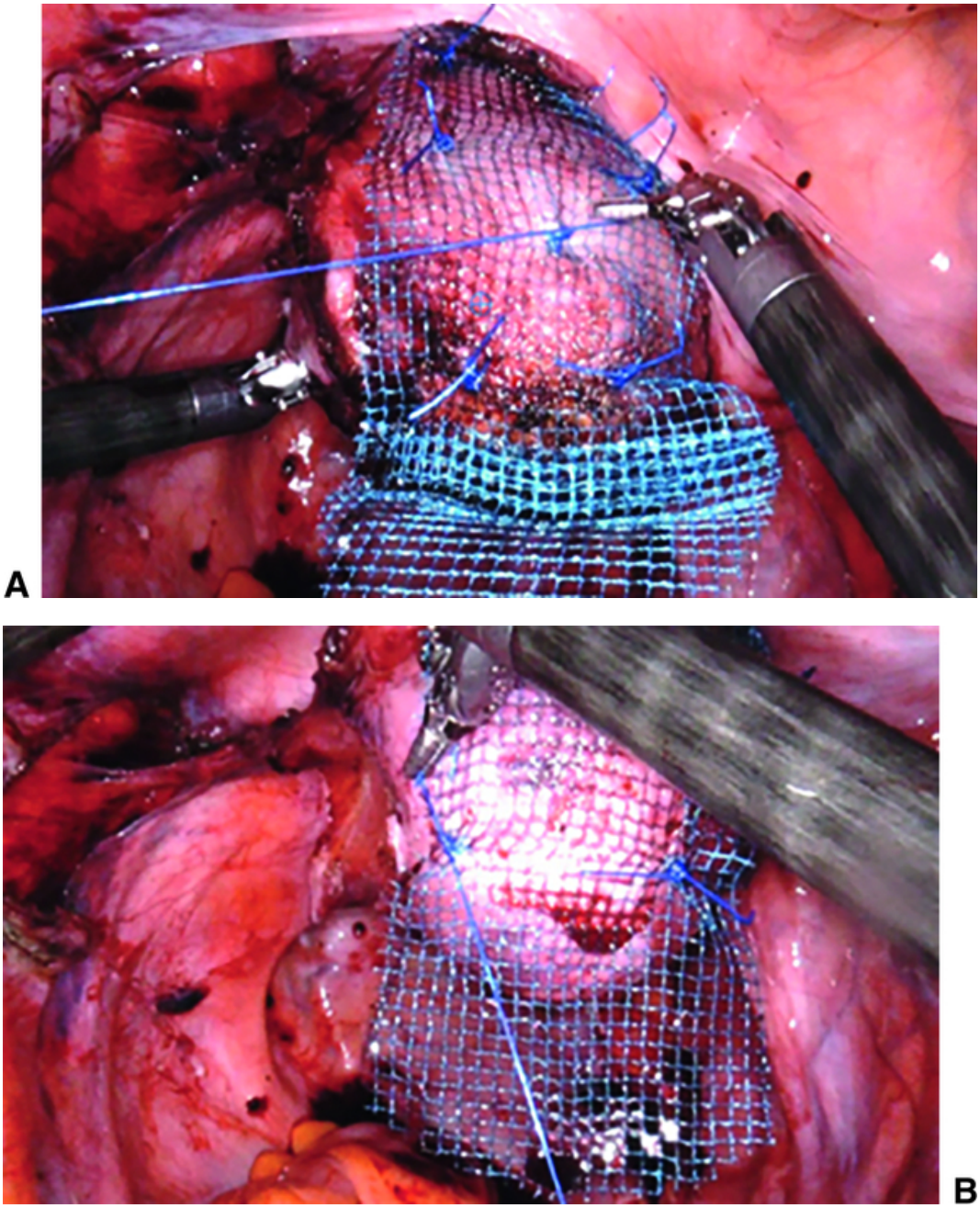


**FIGURE 31.12** Attaching mesh to the vagina. **A.** Attaching the anterior mesh to the anterior

vaginal wall including the cervix if present. **B.** Attaching the posterior mesh to the posterior vaginal wall including the cervix if present.

6. **Sacral Attachment:** The appropriate amount of mesh tension is determined and confirmed by the bedside surgeon (see **FIG. 31.13**.) An EEA is placed in the vagina to reduce tension on the mesh and to facilitate tying of the most distal sacral suture using a sliding knot (see **FIG. 31.14**; **VIDEO 31.1**). We no longer taper the sacral end of the mesh but rather carefully fold the sacral mesh longitudinally and place two additional sutures to secure the double layer mesh to the anterior longitudinal ligament. Any excess mesh can be trimmed and removed.

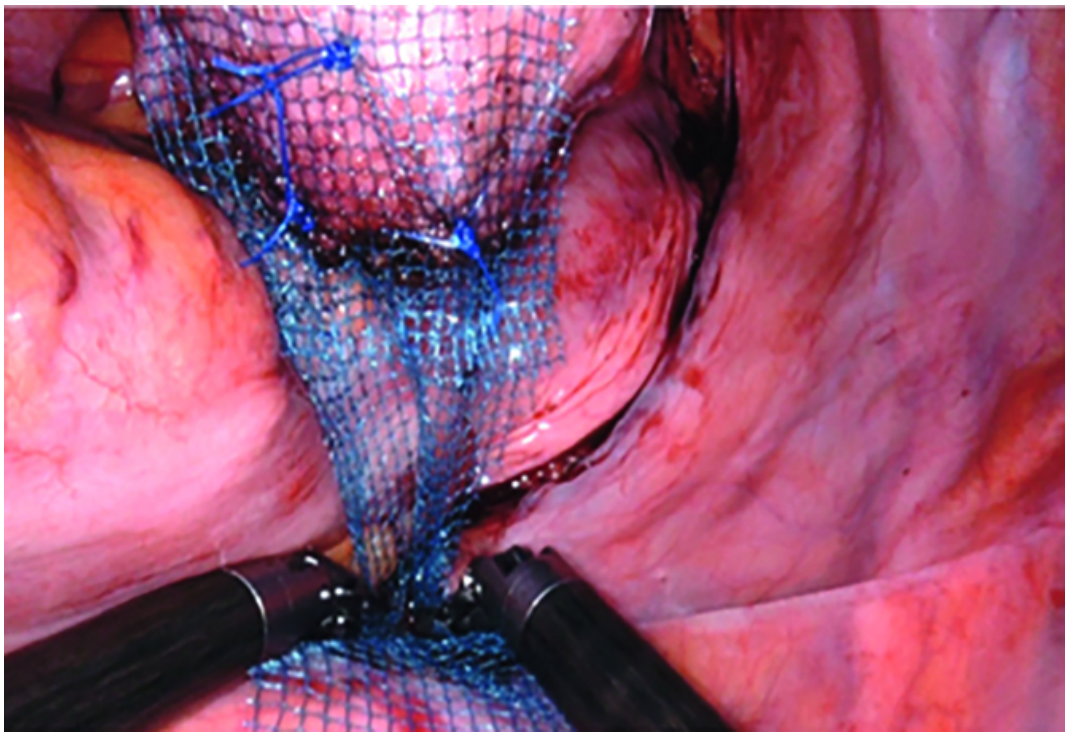


**FIGURE 31.13** Determining the optimal amount of tension on the mesh is confirmed by a vaginal examination after holding the

mesh to the sacrum at the proposed fixation point.

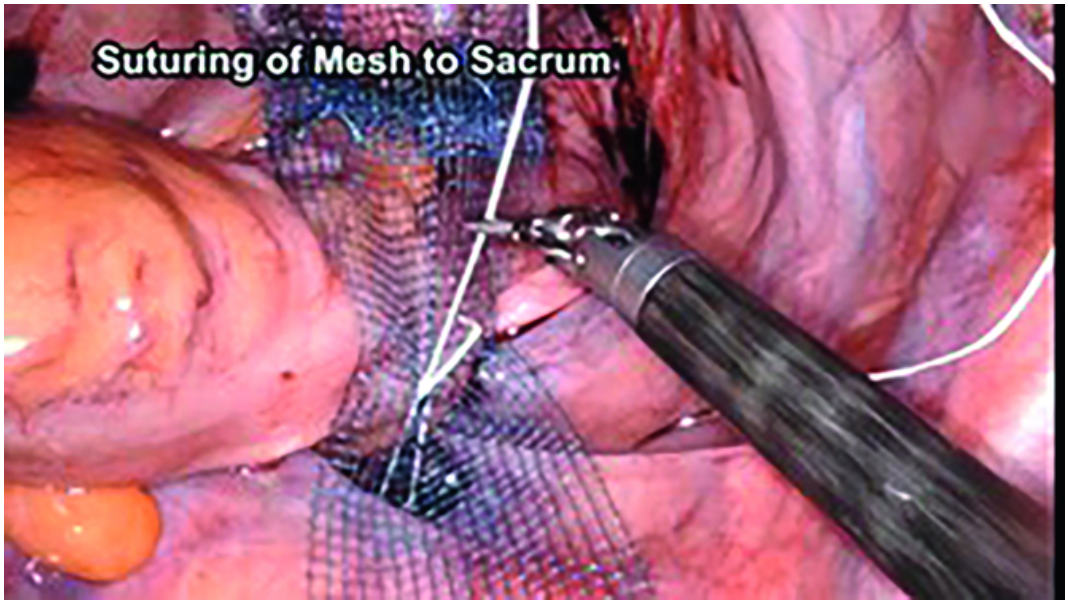



**FIGURE 31.14** Use of a robotically placed slip knot with two additional reinforcing sutures facilitates mesh attachment to the sacrum.

7. **Peritoneal Closure:** We carefully retroperitonealize the mesh, which is intended to help prevent small bowel obstruction. Purposeful dissection of the peritoneum creates full length peritoneal flaps that can be closed over the mesh using 2-0 Vicryl continuous suture. The bedside assistant following along to maintain tension facilitates efficient closure and complete retroperitonealization of the mesh.

## Concomitant Procedures

A vaginal examination is performed after the sacrocolpopexy to assess and confirm whether an anterior or posterior repair is indicated. If so, these can be performed as a concomitant procedure.

A midurethral sling can also be performed, if indicated, after the robotic surgical procedures are completed.

# SURGICAL VARIATIONS

## Sacrohysteropexy

Sacrohysteropexy involves leaving the uterus in place. The sacrocolpopexy mesh is attached along the posterior vaginal wall and cervix. Modifications of this technique involve attachment of anterior mesh arms through windows created in the broad ligament (with the distal ends of the anterior mesh arms attached to the anterior vaginal wall). While not as common and with less data to support its use, it is a reasonable option after a thorough discussion with the patient.

Uterine preservation is relatively contraindicated if there are uterine abnormalities such as fibroids, endometrial hyperplasia, cervical dysplasia, unexplained postmenopausal bleeding, etc.

Further, familial cancer genes such *BRAC1* and *BRAC2* and Lynch syndrome that are associated with uterine carcinoma should be seriously considered before choosing a uterine preserving surgery.

## Sacrocolpoperineopexy

Although concurrent distal posterior vaginal wall defects (rectocele) are typically treated with a concomitant posterior repair, some surgeons advocate a sacrocolpoperineopexy for patients with both a rectocele and associated perineal descent. Perineal descent represents level III loss of perineal body support and is associated with symptoms of obstructed defecation, splinting, and fecal incontinence. This approach was originally described in 1997 by Cundiff et al. This procedure seeks to reestablish continuity between the perineal body and posterior vaginal wall, with the distal end of the mesh attached to the perineal body. Some surgeons perform the perineal body attachment of mesh through a vaginal dissection (passing the mesh into the abdominal cavity via a colpotomy

incision), while others use solely an abdominal/laparoscopic/robotic approach or combination. There is some evidence that a vaginal approach for mesh or suture attachment is associated with a higher risk of subsequent vaginal mesh exposure.

# POSTOPERATIVE CONSIDERATIONS

Patients undergoing minimally invasive sacrocolpopexy can often be safely discharged the same day, assuming that they meet standard postoperative goals. Bladder drainage is recommended during the surgical procedure, but the catheter can be removed immediately after the surgery. A voiding trial (see Chapter 11) is typically recommended to ensure adequate bladder emptying. If removal in the operating room at the end of the surgery, a backfill with ~200 mL of sterile normal saline has been found to reduce the amount of time in the recovery room.

Enhanced recovery after surgery (ERAS) protocols are commonly used after sacrocolpopexy, including minimally invasive approaches. Postoperative pain management is usually managed adequately with nonsteroidal anti-inflammatory drugs as appropriate. Oral narcotics may be needed by some patients for pain refractory to nonnarcotic analgesics.

Patients are generally instructed to observe pelvic rest for 6 weeks until the incisions are fully healed. An earlier resumption of sexual intercourse may be reasonable if there is no vaginal incision (such as when a sacrocolpopexy is performed with concomitant supracervical hysterectomy and no sling or vaginal repairs are performed). Limiting activities that increase intra-abdominal pressure are often recommended for fear that these could increase the risk of recurrent prolapse. Ongoing studies are evaluating this conventional wisdom. Use of over-the-counter stool softeners, especially in patients with baseline constipation is reasonable.

## Outcomes

Data including randomized trials and systematic evidence reviews have consistently shown that sacrocolpopexy provides better

objective anatomic outcomes compared to vaginal surgery. A 2015 systematic evidence review by Siddiqui et al. for the Society of Gynecologic Surgeons Systematic Review Group evaluated five randomized trials and eight cohort studies that compared sacrocolpopexy to native tissue vaginal repairs. They found improved anatomic outcomes associated with sacrocolpopexy, although they found no difference in either reoperation or postoperative sexual function.

The following year, a Cochrane review considered four randomized trials comparing sacrocolpopexy to native tissue vaginal prolapse repairs (with and without mesh augmentation). This study concluded that sacrocolpopexy is associated with lower risk of awareness of recurrent prolapse, a lower risk of recurrent prolapse on examination, less repeat surgery for prolapse, and less dyspareunia.

Vaginal approaches remain a reasonable option, however, as these same studies have shown comparable rates of postoperative symptoms of prolapse, adverse events, and overall reoperation.

With respect to perioperative complications, a major challenge in interpreting the current literature is that many studies include sacrocolpopexies performed through open laparotomy incisions. Today, sacrocolpopexy is typically approached as a minimally invasive procedure. Future comparisons between minimally invasive sacrocolpopexy and vaginal native tissue repair are warranted given the reduction in pain, length of stay, blood loss, GI complications, and recovery time associated with laparoscopic and robotic-assisted approaches.

Recurrent apical prolapse after sacrocolpopexy, while rare, does occur. Such patients often require resection of the previously placed mesh and a complete repeat sacrocolpopexy. This complicated procedure requires advanced surgical training, and we would generally recommend such patients be referred to a surgeon with experience performing these complex procedures. We are typically able to offer outpatient robotic sacrocolpopexy to most patients including those referred to our center with recurrent apical prolapse.

# Complications

Major complications associated with sacrocolpopexy are uncommon. Intraoperative complications associated with sacrocolpopexy are rare but include bleeding, cystotomy, ureteral injury, enterotomy, and proctotomy. Significant intraoperative blood loss is less likely with minimally invasive sacrocolpopexy compared to laparotomy. However, the risk of profuse bleeding from presacral vessels is an always present concern for the experienced surgeon. Hemorrhage, especially from presacral vessels, can be life threatening but is fortunately rare. Previously, significant presacral bleeding required sutures and rarely placement of sterile stainless steel thumbtacks. With the advent of minimally invasive approaches, bleeding is less frequent, and hemostasis can generally be achieved using direct pressure for several minutes along with the use of fibrin containing gel matrix materials such as 5 mL of Floseal (Baxter, Deerfield, IL). Alerting anesthesia and nursing personnel of the presacral bleeding and constant communication with the operating room team is key to a coordinated approach that promotes patient safety.

A systematic review by Diwadkar et al. in 2009 reported a cystotomy risk of 1.0% (range 0.8%-1.3%), ureteral injury risk of 0.2% (range 0.1%-0.3%), and bowel injury risk of 0.5% (range 0.3%-0.7%). A different systematic review by Siddiqui et al. in 2015 for the Society of Gynecologic Surgeons Systematic Review Group reported urinary tract injury risk of 1.5% (0.8%-2.3%) and risk of bowel injury of 0.3% (0.1%-0.6%).

Postoperative complications include wound infections, hernias, ileus, and small bowel obstruction. Small bowel obstructions can occur due to port site hernias, adhesions, internal herniation, and adherence to exposed intraperitoneal mesh. While bowel obstructions after sacrocolpopexy are rare (~1%), a high index for suspicion is critical to make an early diagnosis especially with port site hernias that require immediate surgical intervention. Early treatment may allow for release of incarcerated bowel, obviating the need for a bowel resection. Similarly, bladder and ureteral injuries are equally rare (~1%) but need to be expeditiously identified and corrected.

A meta-analysis that included 5639 patients undergoing sacrocolpopexy and 7827 patient undergoing native tissue apical suspensions found total complication rates similar between approaches. The most common long-term complication is mesh or suture exposure in the vagina. After sacrocolpopexy, mesh exposure has been reported in 3%-4%. However, the rate of mesh exposure depends on the graft material used as well as certain aspects of surgical technique (including whether a total hysterectomy is performed at the time of sacrocolpopexy). The E-CARE study investigators found that mesh exposure continued to increase with time with a cumulative rate of 10.5% by 7 years. Of note, only 48% of CARE Trial participants received a sacrocolpopexy with polypropylene mesh, the currently preferred graft material. This has led many to question how generalizable this study is to our current surgical approach. The important point is that mesh erosion is cumulative over time, and 1-year outcome data are insufficient to fully describe the risk of mesh exposure. Modifiable factors, including smoking and concurrent total hysterectomy, have been shown to increase the risk of mesh exposure. Supracervical hysterectomy at the time of sacrocolpopexy for uterovaginal prolapse appears to reduce the risk of mesh exposure.

While sometimes asymptomatic, mesh exposure can cause vaginal discharge, spotting, dyspareunia, and pelvic pain. Initial management includes a trial of topical vaginal estrogen, but surgical intervention is commonly needed. Surgical management should begin with vaginal excision of the exposed mesh and closure of the vaginal edges. When operating on apical mesh exposures, we use a vaginal Bookwalter retractor to provide excellent exposure throughout the dissection and closure. Most mesh exposures resolve with this single surgical approach. If unsuccessful, the surgeon can discuss another vaginal attempt vs an abdominal approach. Abdominal surgical revision for refractory mesh exposure can typically be performed using minimally invasive techniques, including robotic-assisted laparoscopy. Mesh erosion into the bladder or rectum after sacrocolpopexy should be managed abdominally and can be performed using a robotic minimally invasive approach.

Osteomyelitis and discitis are rare but must remain high on the differential diagnosis in patients presented with back pain or fevers after sacrocolpopexy. This rare complication can present years after the index surgery. In addition to history and physical, blood work to evaluate for leukocytosis, erythrocyte sedimentation rate, and C-reactive protein can help guide management. Magnetic resonance imaging (MRI) of the lumbosacral spine is needed to make the definitive diagnosis of osteomyelitis and discitis. These conditions are treated with long-term IV antibiotics and sometimes require resection of the sacrocolpopexy mesh. Immediate consultation from neurosurgery or spine orthopedic surgery is indicated.

# KEY POINTS

- A growing number of surgeons recommend sacrocolpopexy as primary treatment for advanced stage uterovaginal prolapse or in patients felt to be at high risk for recurrence, while others reserve sacrocolpopexy for treatment of recurrent prolapse.
- Minimally invasive techniques, including robotic sacrocolpopexy, often allow sacrocolpopexy to be offered as a same-day outpatient procedure.
- Important anatomic landmarks for the presacral dissection include the aortic bifurcation, sacral promontory, the right and left common iliac veins, the right ureter, and middle sacral vessels.
- Dissection of the rectovaginal and vesicovaginal spaces is best accomplished with a vaginal stent, such as a smooth rounded end-to-end (EEA) anastomosis sizer or Breisky-Navratil retractor placed in the vagina.
- For sacrocolpopexy, the preferred graft material is a large-pore, lightweight polypropylene mesh, available preconfigured as a Y-mesh.
- The risk of mesh exposure with sacrocolpopexy for vaginal vault prolapse may be 3%-4%. Some studies suggest a higher rate with long-term follow-up.

- Concomitant supracervical hysterectomy for uterovaginal prolapse is thought to reduce the risk of mesh exposure (in comparison to total hysterectomy).
- Use of both monofilament delayed absorbable and monofilament permanent sutures have been reported for mesh attachment to the vagina.

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# CHAPTER 32

# COLPORRHAPHY AND ENTEROCELE REPAIR

Cara Grimes and Patrick Popiel

**Anterior and Posterior Vaginal Wall Prolapse**
**Symptoms Associated With Vaginal Wall Prolapse**
**Anatomy and Function**
Delancey's Levels of Support
Support of the Anterior Compartment
Support of the Posterior Compartment
**Evaluation**
History
Physical Examination
Ancillary Testing
**Initial Management**
**Surgical Management**
General Considerations
Procedures for Repair of Anterior Vaginal Wall Prolapse
Graft Use in the Anterior Compartment
Procedures for Repair of Posterior Vaginal Wall Prolapse
**Enterocele Repair**
Vaginal Enterocele Repairs

Abdominal Enterocele Repairs

**Postoperative Care**

**Outcomes**

# ANTERIOR AND POSTERIOR VAGINAL WALL PROLAPSE

The most common leading edge of prolapse is the anterior vaginal wall. The anterior compartment is also the most difficult to durably repair, and recurrences after any pelvic organ prolapse are most commonly seen in the anterior compartment, with failure rates in the literature up to 50%-70%. Importantly, anterior vaginal wall prolapse is strongly associated with apical prolapse. Rooney et al. demonstrated that when the anterior vaginal wall is at the hymen (ie, Ba = 0), the cervix or cuff (point C) is −4.4 cm from the hymen. Further, anatomic studies have demonstrated that 50% of cystoceles will resolve with proper support of the apex. Thus, it is very important to emphasize that surgical care of anterior vaginal wall support defects almost always requires a concomitant repair of the apex.

The reported prevalence of posterior compartment prolapse varies from 13% to 20% depending on the population studied. Posterior vaginal wall descent is found in ~80% of women who have documented prolapse, with isolated rectoceles occurring in 7% of women. Posterior compartment repair is performed in about 40%-70% of all pelvic floor repairs.

Therefore, while this chapter will focus on identifying and correcting prolapse in the anterior and posterior vaginal compartments, it is important to note that these disorders do not usually exist in isolation and must be evaluated in the context of the entire pelvic floor, as well described in other chapters. When a surgical procedure is chosen to correct pelvic organ prolapse, it is important to consider correcting each anatomical compartment (anterior, posterior, and apical) as well as each level of support.

# SYMPTOMS ASSOCIATED WITH VAGINAL WALL PROLAPSE

Anterior vaginal compartment prolapse can present with symptoms related to impaired anatomy (bulge or protrusion) or function (micturition). Patients with severe anterior vaginal prolapse may complain of obstructive voiding symptoms such as urinary hesitancy, intermittent flow, weak or prolonged stream, feeling of incomplete voiding, splinting to void, and/or urinary retention. Obstructive voiding symptoms are thought to be due to mechanical obstruction resulting from urethral kinking that occurs with progressively worsening anterior vaginal prolapse. Many of these women may also complain of stress urinary incontinence or overactive bladder (see Chapter 33).

Posterior vaginal compartment prolapse can present with symptoms related to impaired anatomy (bulge or protrusion) or function (defecatory dysfunction). There is considerable overlap of defecatory dysfunction with other anorectal disorders, including colonic motility disorders. Posterior vaginal wall prolapse may be associated with defecatory dysfunction, which includes constipation and obstructed defecation. *Constipation* is the complaint that bowel movements are infrequent and/or incomplete and may include the need for frequent straining or manual assistance to defecate. In contrast, *obstructed defecation* refers to defecatory dysfunction specifically due to anatomic and structural abnormalities. Symptoms may similarly include straining (complaint of the need for Valsalva intensively to initiate, maintain, or improve defecation), incomplete emptying/evacuation (the complaint that the rectum does not feel empty after defecation), and splinting/digitation. The latter symptom includes the need to digitally replace a prolapse or to otherwise apply manual pressure to the vagina or perineum to achieve defecation as well as the symptom of the need to manually evacuate or digitalize the rectal canal to assist defecation. However, complaints of defecatory dysfunction are pervasive. In the general population, about 10%-15% of adults complain of constipation; among women seeking treatment for pelvic floor disorders, the

prevalence may be as high as 60%, with complaints including 18%-25% splinting to defecate, 27% straining to defecate, and 26% complaining of incomplete evacuation.

Defects in posterior vaginal compartment support do not necessarily correlate with changes in function. Defecatory dysfunction may be related to systemic causes (endocrine, neurologic, metabolic, psychiatric) and gastrointestinal disorders, that is, “motility disorders” affecting absorption and stool form (constipation—predominant irritable bowel syndrome, functional constipation, colonic inertia, and fecal impaction). Obstructed defecation may result from a variety of anorectal causes (rectal prolapse, neoplasia, anal stricture, anal fissure, prolapsing hemorrhoids, trauma), pelvic organ support defects (rectocele, enterocele, sigmoidocele, perineocele, perineal descent), and coordination of pelvic floor muscles (defecatory dyssynergia). In the setting of symptoms of obstructed defecation, such as splinting, straining, incomplete emptying/evacuation, and splinting/digitation, there is evidence that correcting posterior vaginal wall prolapse leads to some improvement in symptoms.

# ANATOMY AND FUNCTION

## Delancey’s Levels of Support

As noted in Chapter 30 and as illustrated in figures 1.28 and 30.1, there are three levels of support, all of which must be considered during surgery. Level I, the most proximal, provides apical support. The uterosacral and cardinal ligament complex provides support for the cervix and upper vagina and maintains vaginal length. These structures also keep the vaginal axis nearly horizontal so that it rests on the rectum and can be supported by the levator plate **(FIG. 32.1**).

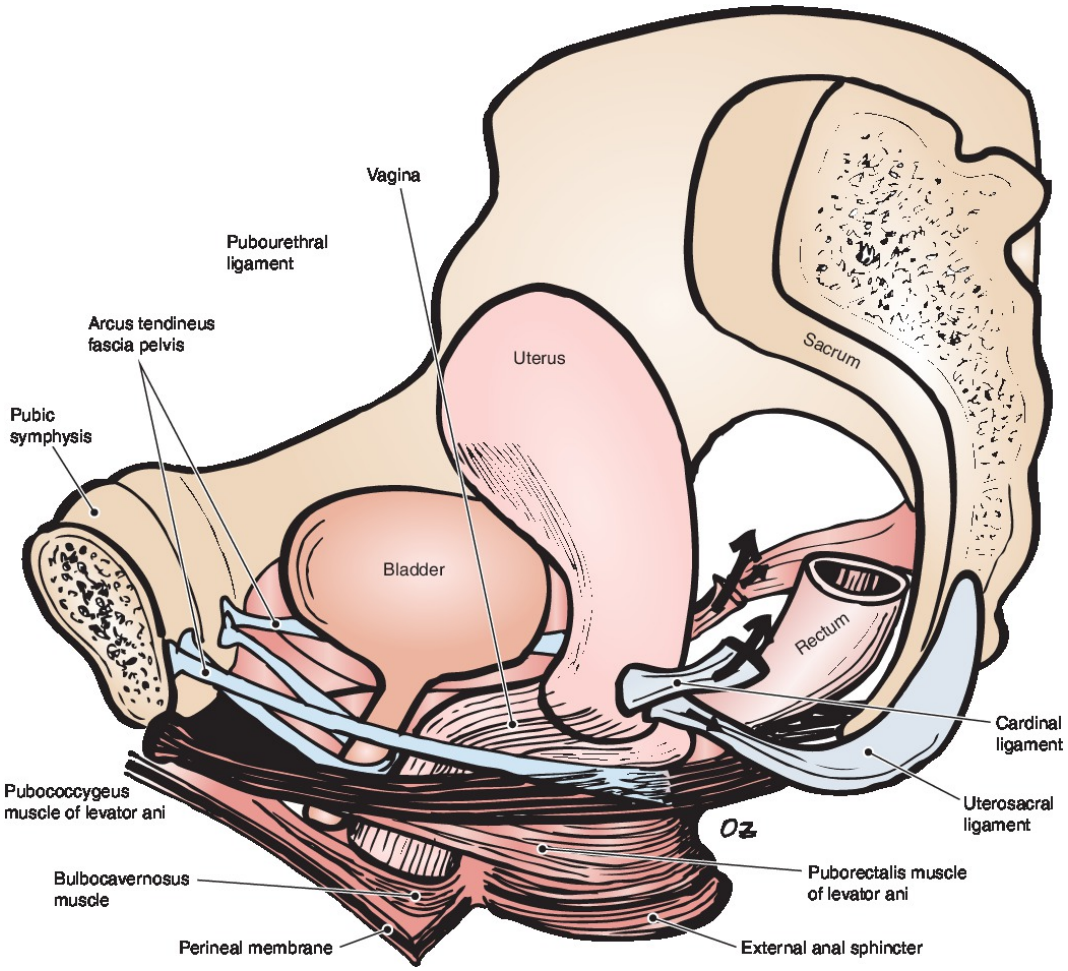



**FIGURE 32.1** Level I support: in the presence of normal support, the vagina is pulled posteriorly toward the sacrum by uterosacral ligaments and to a lesser degree cephalad by cardinal ligaments, resulting in an almost horizontal orientation in the proximal two-thirds.

More distal are the lateral paravaginal supports, level II, which provide the horizontal support of the vagina. The level II supports include a layer of dense fibrous tissue, the fibromuscular layer of the vagina, also sometimes called “endopelvic fascia” or “pubocervical

fascia." Posteriorly, this layer is called the "rectovaginal fascia," "perirectal fascia," or "Denonvilliers fascia." Despite the commonly used terminology of "fascia" for these layers, anatomic studies have shown that endopelvic fascia is not a true fascial layer. The anterior fibromuscular layer of the vagina spreads over the vagina and condenses into the arcus tendineus fascia pelvis ("white line") laterally. These lateral attachments create the anterior lateral vaginal sulci. The rectovaginal fibromuscular tissue is attached superiorly to the uterosacral/cardinal ligament complex, anteriorly to the levator ani/arcus tendineus fascia pelvis, inferiorly to the perineal body, and laterally to the arcus tendineus fascia rectovaginalis (see **FIG. 32.1**). In the proximal posterior vagina, this fibromuscular tissue contains mostly adipose tissue, while the most distal 3-3.5 cm is dense connective tissue without a true cleavage plane.

Finally, the most distal level of support is level III, which consists of the perineal membrane and superficial and deep transverse perineal muscles, external anal sphincter, and bulbocavernosus muscle, which coalesce to form the perineal body. This level provides the lower vertical axis of the vagina and supports and maintains the normal position of the distal one-third of the vagina and introitus. The perineal membrane anchors laterally to the perineal body and distal vagina and anteriorly to the ischiopubic rami (**FIG. 32.2**).

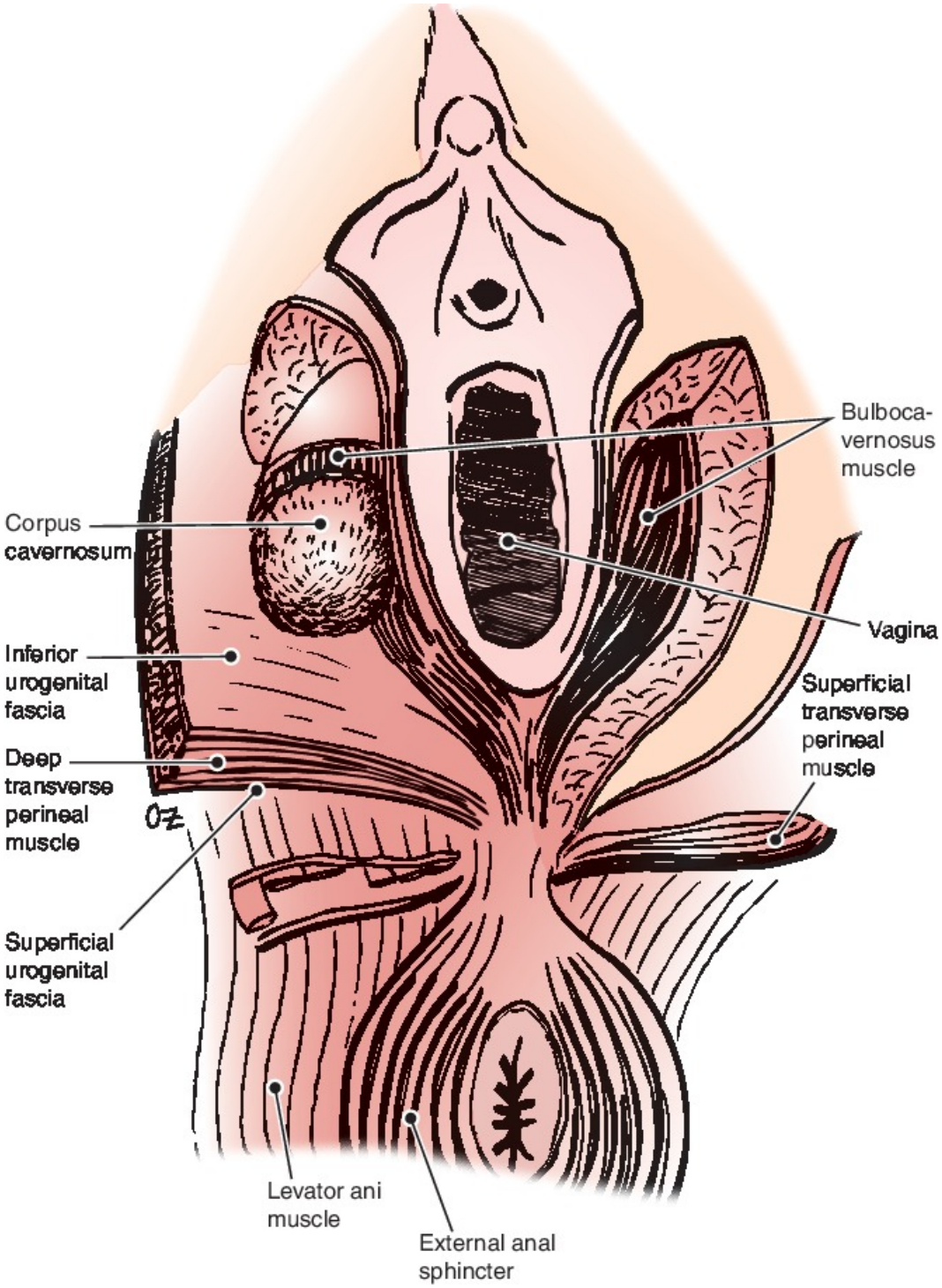



**FIGURE 32.2** Level 3 support: the perineal membrane, superficial and deep transverse perineal muscles, external anal sphincter, and bulbocavernosus muscle coalesce to form the

perineal body. This provides the lower vertical axis of the vagina, supporting the normal position of the distal one-third of the vagina and introitus.

## Support of the Anterior Compartment

Many theories have been proposed to explain the development of anterior vaginal prolapse. Nichols and Randall attributed defects in support of the anterior vaginal wall to either distention or displacement. Distention assumes overstretching of the anterior vaginal wall, leading to damage and attenuation. This may be a result of vaginal delivery and/or atrophic changes from aging and menopause. Evidence for distention on clinical examination may include a decrease or absence in the rugal folds of the vaginal epithelium. Displacement, on the other hand, is thought to be caused by discrete defects in support structures. For example, anterior vaginal prolapse may be caused by a separation laterally between the fibromuscular tissue of the vagina and the arcus tendineus fascia pelvis (paravaginal defect). Similarly, prolapse may arise from transverse defects (separation of fibromuscular layer of the vagina from the cervix), midline defects (anteroposterior separation of the fibromuscular tissue between the bladder and the vagina), and defects involving isolated loss of integrity of pubourethral ligaments (**FIG. 32.3**).

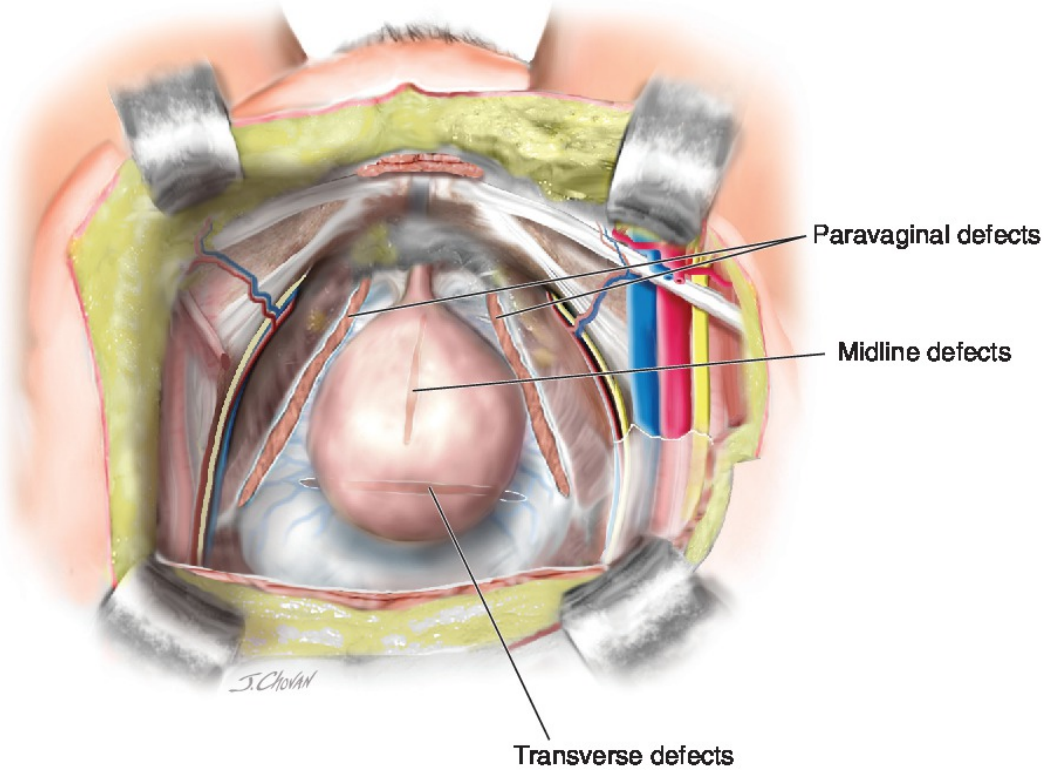



**FIGURE 32.3** Three types of anterior vaginal wall support defects. Lateral or paravaginal defects occur when there is a separation of the pubocervical fascia from the arcus tendineus fascia pelvis, midline defects occur secondary to attenuation of fascia supporting the bladder base, and transverse defects occur when the pubocervical fascia separates from the vaginal cuff or uterosacral ligaments and represents paravaginal, midline, and transverse defects. (Reprinted from Karram MM. *Surgical Management of Pelvic Organ Prolapse.* 1st ed. Saunders; 2013. Copyright © 2013 Elsevier. With permission.)

Recent magnetic resonance imaging (MRI) modeling of vaginal support suggests that apical abnormalities are likely the driving factor in anterior vaginal wall prolapse. The degree of apical descent can explain at least half of the anterior wall descent. According to contemporary research, other factors contributing to the development of anterior vaginal prolapse may include levator muscle impairment, levator avulsion, a greater anterior wall length, and a widened genital hiatus.

## Support of the Posterior Compartment

The posterior vaginal compartment contains the posterior vaginal wall with associated fibromuscular tissue and is bounded by the uterosacral/cardinal ligaments, arcus tendineus fascia pelvis and rectovaginalis, levator ani muscles, and the perineal body and membrane. Posterior compartment prolapse, also called posterior vaginal wall prolapse, is any support defect in this posterior vaginal wall support that allows the rectum (rectocele), small bowel (enterocele), sigmoid colon (sigmoidocele), or perineal body (perineocele) to protrude into the vaginal canal.

# EVALUATION

## History

The evaluation of the anterior and posterior vaginal compartments is part of a comprehensive pelvic floor history. History taking should focus on evaluating symptoms of bulge, urinary incontinence, voiding dysfunction, defecatory dysfunction, and anal incontinence. Symptoms related to bulge include sensation of a vaginal mass or protrusion, pelvic pressure, and sexual difficulty. Since urinary and colorectal symptoms are nonspecific, women with relatively mild or moderate prolapse should be assessed for nonprolapse causes before attributing the symptoms to the prolapse. Specifically, the presence of the following symptoms should be investigated: urinary incontinence; urgency; frequency; nocturia; obstructive voiding symptoms such as urinary hesitancy, intermittent flow, weak or

prolonged stream, feeling of incomplete voiding, splinting to void, and/or urinary retention; and obstructed defecation symptoms such as straining, incomplete evacuation, splinting, and manual evacuation/digitation. If systemic causes of defecatory dysfunction are identified, the patient should be referred to other specialists (gastroenterology, neurology, etc.). In addition, referral should be considered for those presenting with hematochezia, unintentional weight loss, family history of colon cancer or inflammatory bowel disease, anemia, positive fecal occult blood tests, and acute onset of constipation. Validated instruments are helpful in evaluating pelvic floor disorders, including the Pelvic Floor Distress Inventory (PFDI), Pelvic Floor Impact Questionnaire (PFIQ), Bristol Stool Form Scale, Obstructed Defecation Syndrome Questionnaire (ODS), and Rome Criteria, among others. Most subspecialists in Female Pelvic Medicine and Reconstructive Surgery (FPMRS) routinely administer some combination of these validated questionnaires in order to completely assess the symptomatic presentation related to pelvic floor disorders.

# Physical Examination

The evaluation of the anterior and posterior vaginal compartments is part of a complete pelvic examination. The surgeon may elect to initially examine the patient in a standing position. While standing over a chux pad with one foot on the floor and one on a step stool, the patient is asked to Valsalva/strain while the examiner identifies the maximum extent of prolapse. Next, the prolapse is reduced with fluffy, large, cotton-tipped swabs. The apex of the vagina is repositioned in order to roughly approximate a surgical apical correction. This allows the examiner both to evaluate if reducing the apex reduces the visualized prolapse and to perform a reduction cough stress test to evaluate for concomitant occult stress urinary incontinence (see Chapter 33).

The remainder of the examination is performed in the dorsal lithotomy position. In addition to a standard vulvar/vaginal and bimanual examination, a systematic examination of the anterior, posterior, and apical vaginal compartments is performed to evaluate

for pelvic organ prolapse. Most FPMRS surgeons will perform a Pelvic Organ Prolapse Quantification (POPQ) examination, which will quantitate support for each of these compartments. Again, a fluffy, large, cotton-tipped swab can be used to reduce the apex and evaluate whether any apical or posterior compartment prolapse resolves with support of the vaginal apex. Women with severe prolapse and those with symptoms of voiding dysfunction should be evaluated for urinary retention: a catheter can be used to empty the bladder or, alternatively, an ultrasound bladder scanner can be used to evaluate the postvoid residual. Levator ani strength is assessed in order to guide counseling about nonsurgical options including pelvic floor therapy and pessary placement. In women with defecation symptoms and in those with posterior vaginal wall prolapse, a digital rectal examination should be performed to evaluate the rectovaginal septum. Finally, having the patient Valsalva and then contract her levator ani muscles while observing the descent of the vaginal compartments is useful for an overall assessment of the leading edge of the prolapse and to confirm with the patient that the extent of the prolapse seen on examination is consistent with the patient's experience.

# Ancillary Testing

A variety of ancillary tests may be used to evaluate the anterior and posterior compartments, both to further evaluate anatomy and to investigate function. However, these tests are not routinely indicated for the evaluation of every patient presenting with pelvic floor complaints but chosen as part of a tailored and directed workup. Included here are some of the most useful and commonly performed tests.

## *Urodynamics*

Urodynamics, or bladder function testing, can be a useful adjunct to office screening in the setting of bothersome urinary symptoms, or when there is concern for voiding dysfunction (obstructive voiding vs hypocontractile bladder), to evaluate for associated incontinence

prior to surgery, or to assess for occult incontinence. Obstructive voiding symptoms may be due to mechanical obstruction resulting from urethral kinking that occurs with progressively worsening anterior vaginal prolapse.

## *Defecography and Dynamic MRI*

Imaging studies are not part of the routine evaluation of posterior vaginal wall prolapse. Vaginal bulge symptoms are typically evaluated with a physical exam. However, certain imaging studies (including defecography and dynamic MR imaging) may be used to evaluate causes of defecatory dysfunction, such as rectal prolapse, intussusception, enterocele, sigmoidocele, or defecatory dyssynergia. This can be important when considering surgical management, and the cause of a patient's defecatory dysfunction is not clear. Defecography is a fluoroscopic study performed after insertion of radiopaque contrast material into the colon. In some cases, contrast material is also placed in the vaginal cavity and bladder. Defecography provides dynamic visualization of defecation under fluoroscopy. Similarly, dynamic MRI images are obtained while the patient is relaxing and performing a Valsalva maneuver. Dynamic MRI will provide the highest-quality images of the posterior vagina and surrounding structures without exposure to radiation. However, this test may not demonstrate the true extent of prolapse as it is typically performed in a supine position.

Radiologic diagnosis of rectocele has not been standardized. Defecography or dynamic MRI may be useful to identify rectal prolapse or intussusception, or to distinguish a rectocele from an enterocele or sigmoidocele. In addition, imaging may be used to assess for coordinated relaxation of the puborectalis and external anal sphincter muscles with defecation, the absence of which may indicate dyssynergy of the pelvic floor.

## *Anal Manometry*

Anal manometry may be valuable in the assessment of defecatory complaints. This study can identify women with obstructed

defecation due to failure to relax the pelvic floor. Manometry is used to assess rectal function by measuring the resting and squeeze sphincter pressure as well as the functional length of the anal canal. Functional anal canal length is the length of the anal canal over which resting pressure exceeds that of the rectum by <5 mm Hg. Rectal compliance reflects the capacity and distensibility of the rectum. Higher compliance indicates lower resistance to distention.

# INITIAL MANAGEMENT

Pelvic organ prolapse in any compartment is approached similarly. First, conservative measures are discussed. For example, defecatory symptoms may prompt advice, including diet/stool softening and voiding and defecating strategies including position changes, splinting, etc. Pelvic floor muscle strengthening may be considered as a primary therapy, either via a home exercise program, possibly augmented by the use of vaginal cones, or via a supervised pelvic floor therapy program. Randomized trials have shown that supervised programs of pelvic muscle strengthening are effective in reducing prolapse symptoms and objective prolapse severity, although to date all of the clinical trials have considered only short-term outcomes. Pessaries should be offered as well. These may serve as excellent long-term solutions for patients or as a bridge to surgical treatment.

# SURGICAL MANAGEMENT

## General Considerations

Surgery can be considered for women with symptomatic prolapse who do not achieve symptomatic control with conservative measures and for those who elect primary surgical management. Preparation for surgery starts with choosing the appropriate surgical procedure. The selection of surgical approach should address the patient's symptoms, anatomic findings, and her goals for surgery. The informed consent discussion should include the risks and benefits of

the procedure, and expected outcomes/success rates. Important topics to discuss regarding surgical treatment of anterior or posterior compartment prolapse include the risk of recurrence or *de novo* prolapse in another compartment; the impact on symptoms of micturition or defecation; the risk of bladder, ureteral, or bowel injury; and the risk of vaginal scarring and dyspareunia.

The night before and day of surgery, patients follow standard preoperative and Enhanced Recovery After Surgery (ERAS) recommendations. A bowel preparation is not usually necessary and a full rectum can be manually evacuated by the surgeon prior to prepping and draping. Standard antibiotic prophylaxis for urogynecologic procedures (usually a first-generation cephalosporin) and venous thromboembolism (VTE) prevention is followed. If the peritoneal cavity will be entered during the procedure, then a general anesthetic (with endotracheal intubation vs laryngopharyngeal mask) can be used to protect the airway as paralysis is needed. Otherwise, moderate sedation with a laryngeal mask airway (LMA) mask or spinal or epidural anesthesia is an appropriate choice.

The patient is positioned in high dorsal lithotomy taking care to pad extremities and pressure points and to place the legs in a neurologically neutral position. Chlorhexidine (without alcohol) or povidone-iodine vaginal prep are appropriate alternatives for prepping. A Foley catheter is placed. A standard vaginal procedure tray with the addition of pelvic reconstructive instruments is needed. This will usually include weighted speculums, Heaney needle drivers, Allis clamps, Allis-Adair clamps (or T clamps), Breisky-Navratil or malleable retractors, and Metzenbaum scissors. A Lone Star retractor is often a useful tool, especially when there is no qualified assistant available. Sutures used include 2-0 and 0 delayed absorbable monofilament sutures, such as PDS (Ethicon) on CT-1 or 2 needles or Maxon (Covidien) on GS-21 or 22 needles, 2-0 braided absorbable sutures such as Vicryl (Ethicon) on a CT-2 needle, or Polysorb (Covidien) on a GS-22 needle.

## Procedures for Repair of Anterior Vaginal Wall Prolapse

The goal of surgical repair of the anterior vaginal compartment is twofold: to reduce an anatomic bulge and to improve any related symptoms. As the majority of defects in the anterior compartment support coincide with an apical defect, a focused anterior compartment repair is often performed concomitantly with a vaginal apical suspension, such as that described in Chapter 30.

The anterior compartment can be approached transvaginally or abdominally (including open vs minimally invasive techniques). Repairs can also be divided into native tissue repairs and graft-augmented repairs. The most common techniques for repairing the anterior vaginal compartment include anterior colporrhaphy, anterior colporrhaphy with graft, and paravaginal repair (either vaginal or abdominal/minimally invasive approach). When an anterior vaginal wall prolapse is encountered concomitantly with an apical prolapse, correction of the apical prolapse is an important component of the surgery.

# *Anterior Colporrhaphy*

The goal of an anterior colporrhaphy is to plicate the attenuated fibromuscular layer of the vagina to repair midline tissue defects, reinforce/thicken the fibromuscular tissue, and reposition the bladder anteriorly.

The patient is positioned in dorsal lithotomy with legs in yellow fins or candy cane stirrups. A Foley catheter is placed. A weighted vaginal speculum and/or a Lone Star retractor are useful.

If the vaginal cuff has already been created, either after completion of a vaginal hysterectomy or by entering the retroperitoneal space for a sacrospinous ligament suspension, then Allis-Adair clamps are used to grab the cuff transversely (ie, at the most dependent proximal portion of the prolapse), and this will serve as the proximal extent of the dissection. In an isolated anterior colporrhaphy when there is good apical support (uterus or cuff), the most proximal aspect of the repair is just proximal to any identified defect or weakness; this spot is usually about 1-2 cm distal to the apex.

Next, an Allis clamp is placed at the level of the urethrovesical junction. The urethrovesical junction is ~3-4 cm from the urethra meatus and can be discerned by placing a Foley catheter in the bladder. Gentle traction applied on the Foley will place the Foley bulb at the bladder neck, and the Allis clamp can be placed just distal to the Foley bulb, which will be at the urethrovesical junction. Dissection is not carried further distally.

A dilute vasopressin solution or local anesthetic with epinephrine is injected in the midline and out laterally to the sidewalls. A midline incision is made with a scalpel or Bovie from the distal Allis to the proximal Allises (**FIG. 32.4A**). The edges of the vaginal epithelium are grasped with Allis-Adair clamps and sharply dissected off the underlying fibromuscular tissue with Metzenbaum scissors (**FIG. 32.4B**). This dissection is carried out laterally toward the ischiopubic rami until good fibromuscular tissue is encountered (**FIG. 32.4C and D**). The underlying fibromuscular layer of the vagina is then plicated to itself with sutures to reduce the prolapse (**FIG. 32.4E**). Usually, interrupted sutures are used to plicate the underlying fibromuscular tissue. Care is taken not to plicate too laterally as this can result in ureteral kinking and obstruction, and, rarely, vaginal stenosis (narrowing of the vaginal tube). Interrupted sutures prevent bunching and shortening of the anterior vaginal wall, which can lead to dyspareunia and a foreshortened vagina. However, in cases of very advanced prolapse with an extremely attenuated anterior vaginal wall, a running suture, or running locked suture, can be used if shortening the vaginal wall is desired. Finally, the vaginal epithelium is trimmed (**FIG. 32.4F**) and closed with 2-0 absorbable braided suture. While trimming the vaginal epithelium, care is taken not to excise excess vaginal epithelium as that can result in vaginal stenosis or unnecessary tension on the closure leading to wound separation. Many surgeons close the vaginal epithelium with a running locked suture in order to preserve vaginal length and avoid dyspareunia. Alternatively, the anterior vaginal wall can be closed with interrupted sutures.

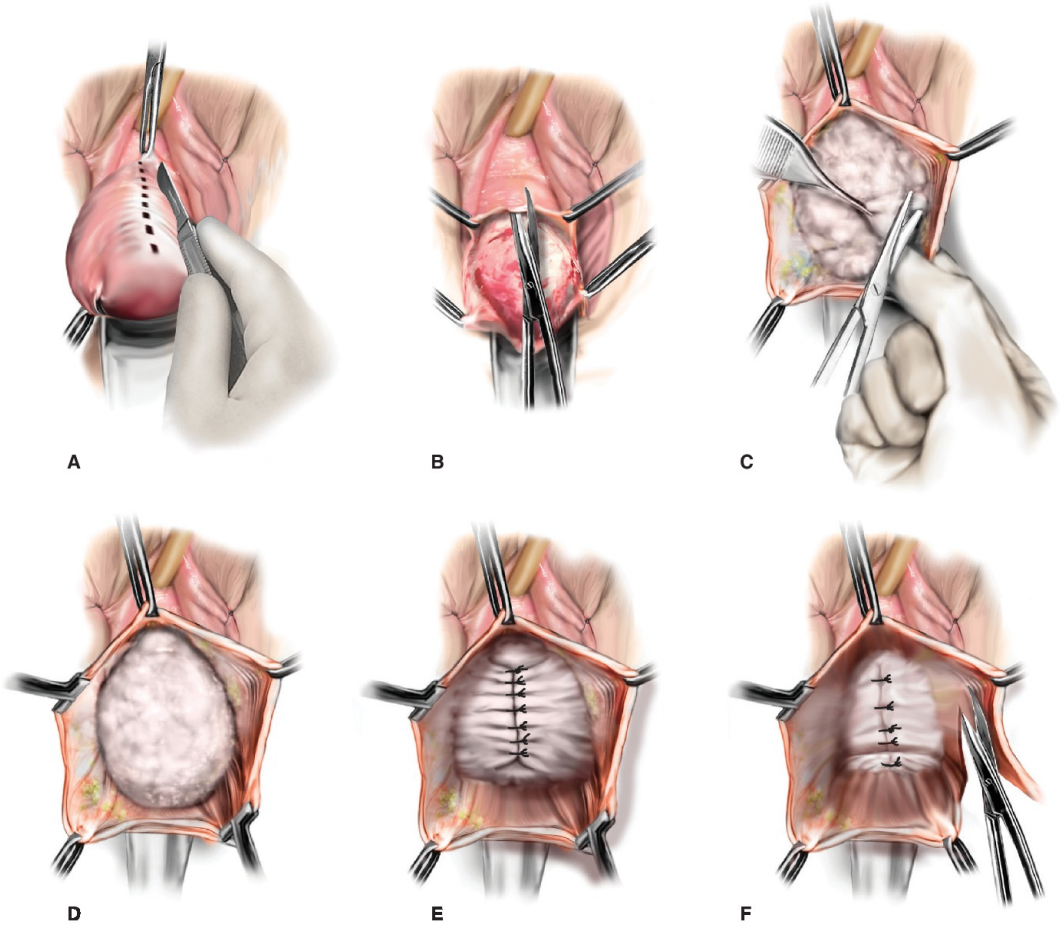



**FIGURE 32.4** Classic anterior colporrhaphy. **A.** Initial midline anterior vaginal wall incision is demonstrated. **B.** The midline incision is extended using scissors. **C.** The vagina is sharply dissected off the underlying fibromuscular tissue, continuing laterally to the superior pubic ramus. **D.** The dissection is complete. **E.** Initial plication layer is placed. **F.** Vaginal wall is trimmed.

At this time, if a concomitant apical suspension is to be performed, the apical suspension sutures should be tied to reapproximate the

apical part of the vagina. Complete resolution of the apical and anterior compartment should be noted at this time. If an anti-incontinence procedure is planned, it is performed at this point. Cystoscopy is recommended after every anterior colporrhaphy to confirm that the ureters are patent and not kinked or obstructed due to a wide lateral dissection and aggressive plication. During cystoscopy, the entire bladder mucosa should be evaluated to ensure that no sutures have been placed in the bladder. Both ureters should be evaluated for patency, and the urethra should be examined in its entire length upon withdrawal of the cystoscope.

Most prospective studies on isolated anterior colporrhaphy (without concomitant apical support procedure) demonstrate anatomic success rates ranging from 37% to 83% at 1-2 years of follow-up.

## *Vaginal Paravaginal Repair*

Some women with anterior vaginal prolapse demonstrate a clear detachment of the lateral vaginal tissue from the arcus tendineus fascia pelvis, and the vagina can be seen ballooning laterally. In this scenario, a paravaginal repair may be considered, though evidence-based data are lacking to support or refute this approach. Paravaginal repairs can be approached vaginally via a native tissue or graft-augmented repair, or abdominally via laparotomy or minimally invasive retropubic approach.

A goal of the paravaginal defect repair is to reattach the lateral vaginal wall to the arcus tendineus fascia pelvis. When performed vaginally, it is initially approached similarly to an anterior colporrhaphy. After the longitudinal incision is made in the vaginal epithelium and the underlying fibromuscular tissue is dissected off of the overlying epithelium, the dissection is carried further laterally until the paravaginal spaces are entered on each side. The paravaginal space is developed bluntly between the vaginal wall and obturator internus muscle. To do this, the surgeon’s index finger can be used to extend the space anteriorly along the ischiopubic rami, medially/anteriorly to the pubic symphysis, and laterally/posteriorly toward the ischial spine. If a paravaginal defect is present and

dissection is occurring in the appropriate plane, it is easy to enter the retropubic space and visualize the retropubic and paravaginal adipose tissue. The ischial spine should be palpable on each side through this dissection. The arcus tendineus fascia pelvis can be followed from the ischial spine, running underneath the ischiopubic ramus to the posterolateral aspect of the symphysis pubis. It can sometimes be palpated (feels like a thinned stretchy rubber band).

The vaginal paravaginal repair is a three-point closure involving the vaginal epithelium, fibromuscular layer of the vagina, and lateral pelvic sidewall at the arcus tendineus fascia pelvis. Sutures are systematically placed in the arcus tendineus fascia pelvis (point 1), through the fibromuscular layer of the vagina (point 2), and then the vaginal epithelium as described below (point 3). While retracting the bladder and urethra medially with a malleable or Breisky-Navratil retractor, three to six sutures are placed into the arcus tendineus fascia pelvis. If three sutures are placed, the first is placed just anterior to the ischial spine, the second is halfway to the pubic symphysis, and the third is just lateral to the pubic symphysis (**FIG. 32.5A**). A Capio device (Boston Scientific, Natick, MA) can facilitate the placement of either delayed absorbable monofilament or permanent monofilament sutures. The procedure is performed bilaterally if the patient has bilateral paravaginal defects. At this stage, a midline plication can be performed as in a traditional anterior colporrhaphy. Afterward, attention is turned back to the previously placed sutures in the arcus tendineus fascia pelvis. Starting with the most anterior stitch, the needle is placed into the edge of the fibromuscular layer of the vagina at the level of the urethrovesical junction (**FIG. 32.5B**) and then through the vaginal epithelium (**FIG. 32.5C**). If permanent sutures are used, the vaginal epithelium should be excluded. Subsequent stitches are placed posteriorly until the last stitch closest to the ischial spine is attached to the vagina nearest the apex. The stitches are then tied in order from the urethra to the apex, alternating from one side to the other. There must be tissue to tissue approximation between these structures, that is, suture bridges must be avoided by careful planning of suture placement. The vaginal epithelium should not be trimmed until all of the stitches are tied. The epithelial flaps are

trimmed and closed with a running locked delayed absorbable suture.

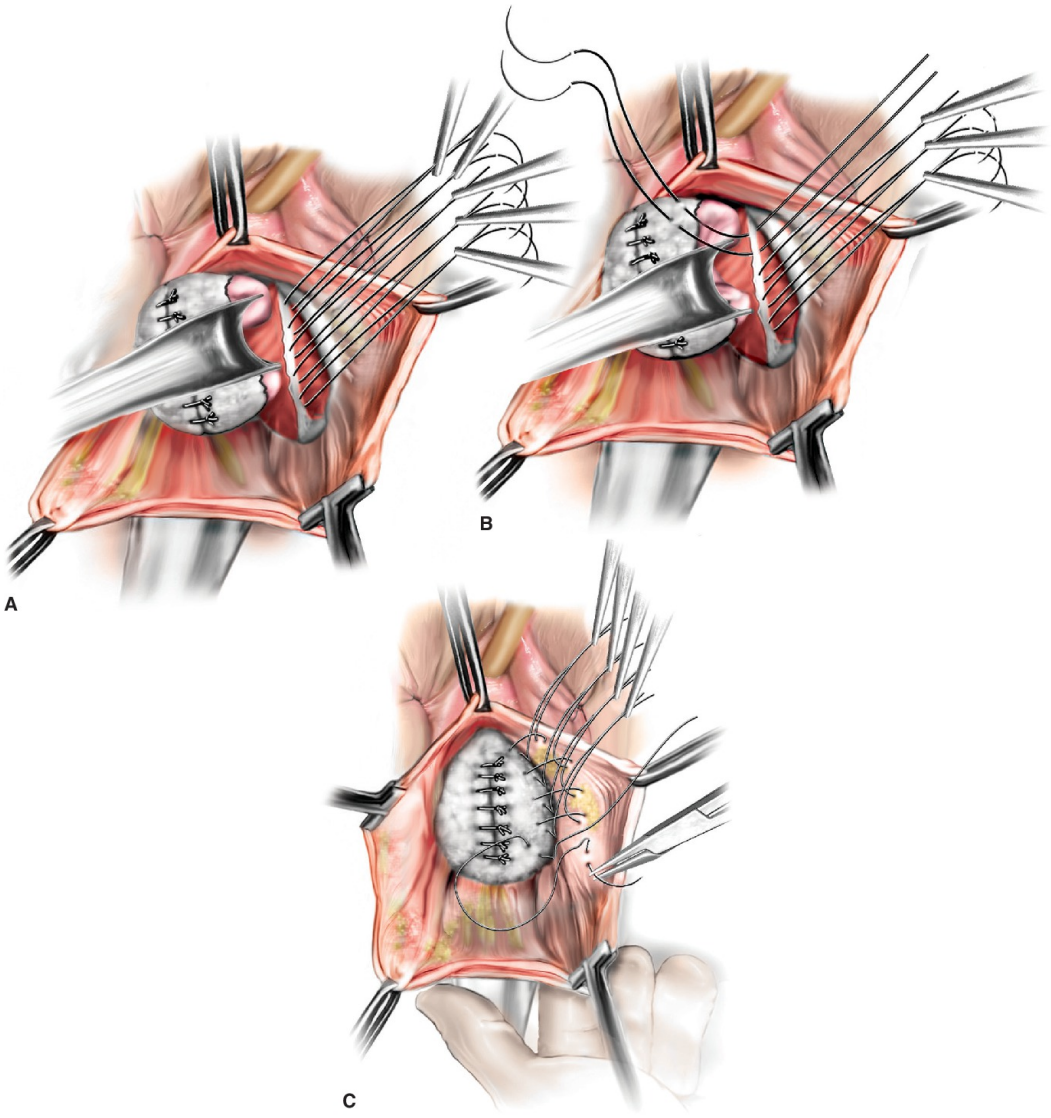



**FIGURE 32.5** Surgical steps for vaginal paravaginal (3-point) repair. **A.** Three to six sutures are passed through the *white line* on the fascia over the obturator internus muscle (point 1). **B.** One end of each suture is passed through the lateral edge of the detached

fascia (point 2). **C.** Each suture is passed through the full thickness of the vaginal wall excluding the epithelium (point 3). (Reprinted from Karram MM. *Surgical Management of Pelvic Organ Prolapse*. 1st ed. Saunders; 2013. Copyright © 2013 Elsevier. With permission.)

## *Abdominal Paravaginal Repair*

Paravaginal repair can also be performed via an abdominal approach, approached either via a Pfannenstiel incision or via a minimally invasive approach. After entering the peritoneal cavity via either method, the retroperitoneal space is entered and the bladder is freed from the pelvic sidewalls using blunt and sharp/electrocautery dissection. The space of Retzius (see **FIG. 33.13**) is entered, taking care to avoid the retropubic venous plexus. The goal is to visualize the posterior aspect of the pubis symphysis, Cooper ligaments, obturator internus muscles, and the arcus tendineus fasciae pelvis and the bladder neck.

The surgeon places a finger into the vagina to delineate the structures and help deviate the vagina and bladder medially. Sutures are placed, starting near the vaginal apex. The initial suture is placed, first through the full thickness of the vagina (excluding the vaginal epithelium) and then deep into the obturator internus fascia or arcus tendineus fascia pelvis, 1-2 cm anterior to its origin at the ischial spine. After this first stitch is tied, additional sutures (two to five) are placed through the vaginal wall and overlying fascia and then into the obturator internus at about 1-cm intervals toward the pubic ramus (**FIG. 32.6**). No. 2-0 or 0 permanent monofilament suture is usually used for the paravaginal repair. Before the sutures are tied, cystourethroscopy is performed to rule out suture passage through the bladder and to confirm ureteral patency. After cystourethroscopy, the sutures are tied and cut.

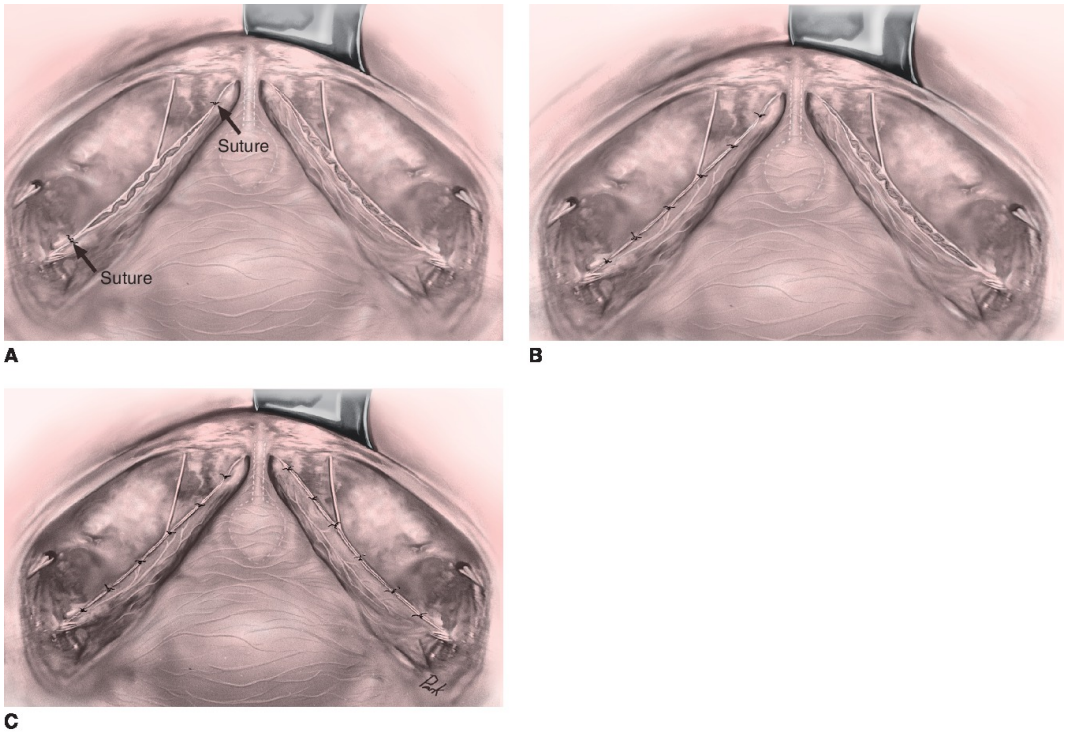



**FIGURE 32.6** Abdominal paravaginal defect repair reattaches the pubocervical fascia to the *white lines* bilaterally. **A.** A patient with bilateral paravaginal defects. The repair has been started on the left with sutures at the two extremes of the defect. **B.** The repair is complete on the left side. **C.** Both sides are repaired.

Outcome data for paravaginal repairs are limited to single-site case series. These studies suggest success rates for the vaginal approach between 67% and 100% and 75%-97% for the abdominal approach (open). Scant data exist for laparoscopic paravaginal repairs. Of note, vaginal paravaginal repairs may be associated with a high estimated blood loss and transfusion rate, up to 21% in one study.

## Graft Use in the Anterior Compartment

The philosophy behind graft augmentation is to reinforce weakened tissue (that may or may not be concomitantly plicated) and provide lateral and midline support. Grafts work by providing a scaffold that allows for host tissue ingrowth and creates an artificial reinforced level II support that is usually connected proximally to level I support and distally to level III support.

Graft materials may be synthetic or biologic. The latter includes autologous fascia (fascia lata, rectus fascia), allografts (cadaveric fascia lata, cadaveric dermis, dura mata), and xenografts (porcine dermis, porcine small intestine submucosa, bovine pericardium, bovine dermis). A graft or mesh can be used to augment an anterior colporrhaphy or vaginal paravaginal repair. Mesh or graft is cut into a trapezoidal shape, often with arms for apical attachment. After a full-thickness epithelial dissection, the distal edge of the graft or mesh is secured to the anterior vaginal wall. Next, the lateral edges of the graft/mesh are sutures to the lateral aspect of the anterior vaginal wall, or incorporated into the sutures placed for the paravaginal repair, thus fixing it to the arcus tendineus fascia pelvis. Finally, the apical arms can be secured to the sacrospinous ligaments, thus providing apical support (**FIG. 32.7**).

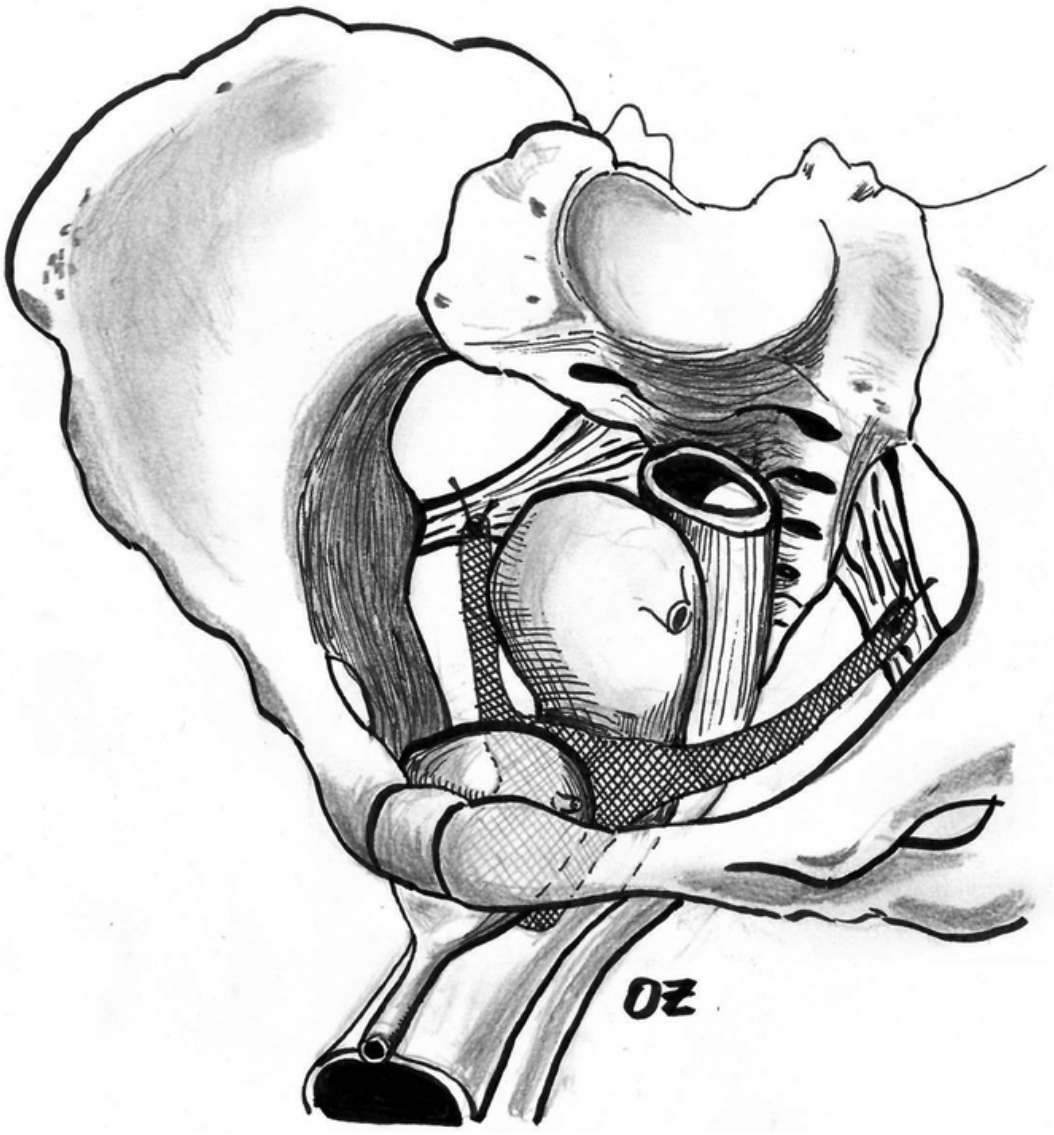



**FIGURE 32.7** A mesh or graft can be used for anterior and apical vaginal prolapse. This is often done through a full-thickness anterior vaginal wall dissection, and the arms of the mesh are secured to the sacrospinous ligaments bilaterally, providing anterior and apical support. (Courtesy of Dr. Oz Harmanli.)

Previously available mesh “kits” are no longer commercially available in the United States. In 2008, the Food and Drug Administration (FDA) released a Public Health Notification regarding the use of synthetic mesh placed transvaginally (ie, mesh that passes through the vagina and is placed under the vaginal epithelium). The notification stated that surgeons and patients should be aware of complications associated with mesh, including mesh erosion and exposure. The FDA made several recommendations, including the need for adequate informed consent and specialized training for specific mesh kits. In 2011, the FDA issued a Safety Update that further stated that the complications noted in the 2008 Public Health Notification were “not rare.” The FDA ordered medical device companies to perform postmarket surveillance studies on mesh kits for prolapse. In 2016, transvaginal mesh was reclassified to a class III (high risk) medical device. Thereafter, in April 2019, the FDA ordered that these devices be withdrawn from the market. These warnings have dramatically decreased the use of transvaginal mesh for prolapse.

In a 2016 systematic review, Maher et al. concluded that graft/mesh has minimal anatomic and subjective advantage compared to native tissue repair and is associated with increased morbidity. However, native tissue repair was associated with increased persistence of bulge/protrusion symptoms after surgery, increased recurrence of anterior compartment prolapse, and increased risk of repeat surgery. Native tissue repair was associated with lower risk of *de novo* stress urinary incontinence and a lower incidence of bladder injury. Similarly, in another 2016 systematic review by Schimpf, the use of synthetic mesh transvaginal was found to improve anatomic outcomes and was associated with lower rates of vaginal bulge symptoms compared to native vaginal tissue repairs. In this review, 20 studies compared nonabsorbable mesh to native vaginal tissue repair in the anterior compartment. The mesh exposure rate ranged from 1.4% to 19%. Most exposures were managed conservatively. Mesh revision rates were 3%-8%. Thus, in properly selected patients who understand the risks of transvaginal mesh, it is reasonable to consider mesh augmentation for anterior

prolapse repair, but it is unclear as to how much these costs and risks outweigh the benefits (**BOX 32.1**).

# BOX 32.1 STEPS IN THE PROCEDURE

## Anterior Compartment Repair

*Anterior Colporrhaphy (Midline Plication) +/− Paravaginal Repair +/− Graft Augmentation*

1. Use Allis clamps to delineate the area of dissection on the vaginal mucosa (proximal and distal ends of the prolapse).
2. Inject vasopressin for hemostasis and hydrodissection.
3. Incise vaginal epithelium.
4. Dissect the fibromuscular tissue off the overlying vaginal epithelium. [If a concomitant paravaginal defect exists, the dissection is carried laterally to the paravaginal spaces from the pubic symphysis to the ischial spine and the arcus tendineus fascia pelvis is identified. Three to six sutures are placed into the arcus tendineus fascia pelvis and held].
5. Reduce the anterior defect with sutures (**midline plication**). This is done with interrupted sutures, but occasionally running sutures can be used if vaginal shortening is desired.
6. If a paravaginal repair is being performed, the paravaginal sutures in the arcus tendineus fascia pelvis (step 4) are placed into the vaginal fibromuscular tissue and then into the vaginal epithelium to reattach the vagina to the lateral support (arcus tendineus fascia pelvis).
7. If **graft augmentation** is being performed, the paravaginal sutures can be placed through the graft arms and tied down.
8. Trim excess vaginal epithelium.
9. Reapproximate the edges of the vaginal epithelium with absorbable suture.
10. Tie down apical sutures if performed concomitantly with an apical repair.
11. When indicated, perform an anti-incontinence procedure through a separate incision.

12. Check vaginal caliber with a digital vaginal examination and ureteral integrity with cystoscopy.

# Procedures for Repair of Posterior Vaginal Wall Prolapse

The goal of surgical repair of the posterior vaginal compartment is twofold: to reduce an anatomic bulge and to improve any related symptoms.

The posterior compartment can be approached transvaginally, transanally (endorectal), and abdominally (open vs minimally invasive techniques). Repairs can also be divided into native tissue repairs and graft-augmented repairs.

## *Posterior Colporrhaphy and Site-Specific Posterior Repair*

The two most common transvaginal, native-tissue repairs are midline plication, also called a traditional posterior colporrhaphy, and the site-specific repair. Often, these repairs are augmented by a perineorrhaphy. A perineorrhaphy is a reconstruction of the perineal body with the goal of rebuilding the perineum. Perineorrhaphy may include a reapproximation of the superficial and deep transverse perineal muscles and bulbocavernosus muscles. The goal of perineorrhaphy is to repair level III support, increasing the length of the perineal body (pb) and decreasing the length of the genital hiatus (gh). There is emerging evidence that a narrower genial hiatus at time of sacrocolpopexy or vaginal apical prolapse repair is associated with decreased risk of prolapse recurrence, increased patient satisfaction, and improved the sensation of a wide vagina. However, often the genital hiatus will decrease with the apical suspension alone and does not require perineorrhaphy. At this time, there is no gh measurement that necessitates a perineorrhaphy and it remains up to the surgeon’s judgment to determine when the perineal body needs rebuilding with a perineorrhaphy.

## *Midline Plication/Traditional Posterior Colporrhaphy +/− Perineorrhaphy*

If a perineorrhaphy is planned as part of a posterior colporrhaphy, Allis clamps are used to grasp the vaginal epithelium at the level of the hymen on each side of the proposed perineorrhaphy, usually at 4 and 8 o'clock positions, and also at the most proximal portion of the posterior vaginal epithelium (proximal to the bulge) in the midline. Approximation of the Allis clamps in the midline will give the surgeon a good estimate of vaginal caliber after the procedure. The reconstructed vagina should be able to accommodate two to three fingers comfortably.

If no perineorrhaphy is planned, the procedure begins by grasping vaginal epithelium with Allis claps to delineate the proximal and distal ends of the prolapse (eg, by grasping the posterior vaginal epithelium longitudinally in the midline).

A dilute vasopressin (20 units in 50 or 100 mL normal saline) or local anesthetic with epinephrine solution is injected in the midline and out laterally to the sidewalls for hemostasis and hydrodissection. If performing a perineorrhaphy, a triangular portion of the vaginal epithelium is removed transversally from the posterior aspect of the vaginal wall, along with the perineovaginal epithelium using curved Mayo scissors (**FIG. 32.8**).

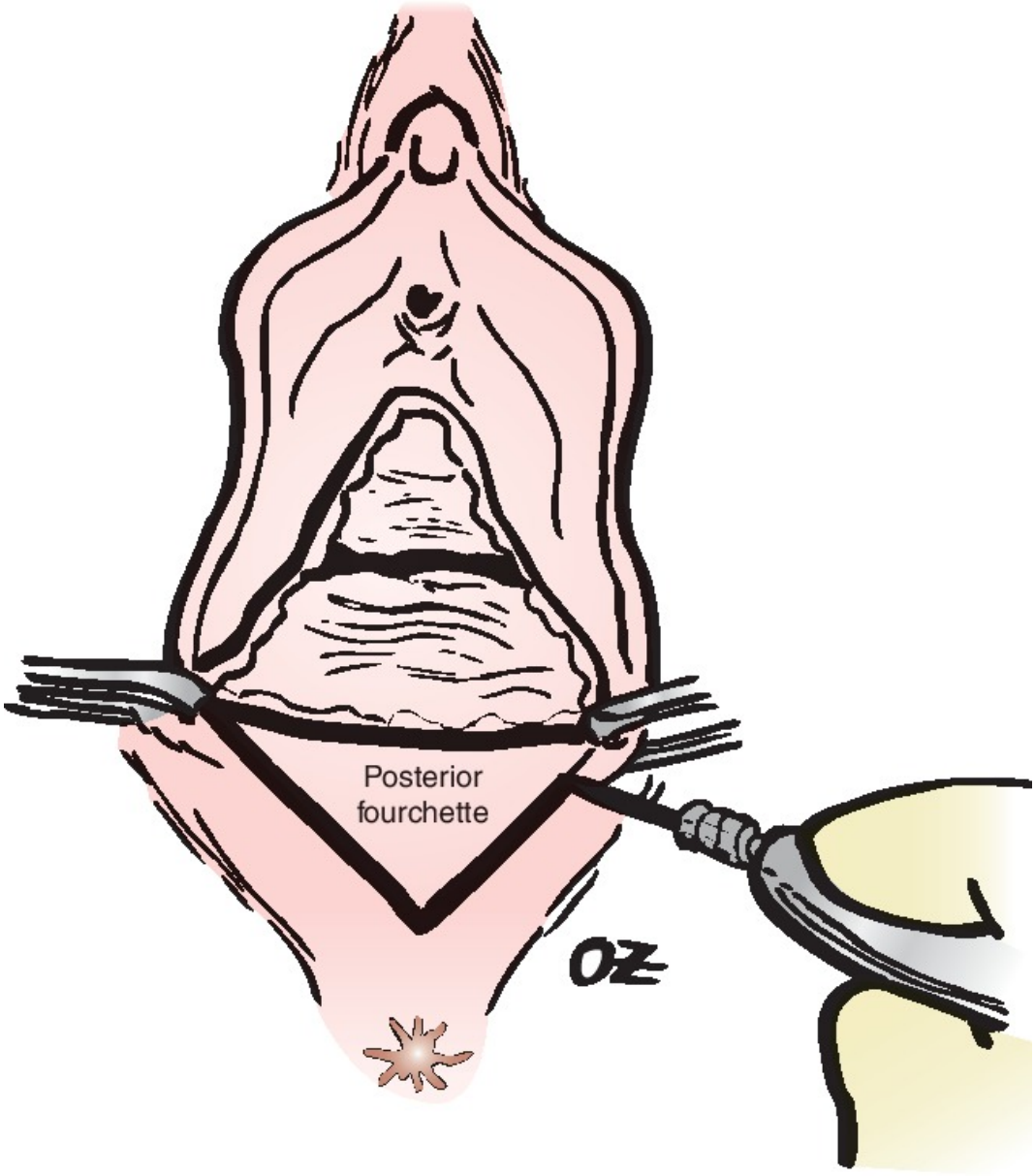



**FIGURE 32.8** Perineorrhaphy: after assessment of targeted introital dimensions by placing Allis clamps on each side of the posterior hymenal ring, a triangular incision is made on the posterior fourchette and the epithelium within this triangle is removed.

After the hemostatic solution is injected, a longitudinal midline incision is made with the scalpel to the proximal Allis clamp to allow access to the underlying fibromuscular tissue. Alternatively, this incision can be created by inserting the Metzenbaum scissors under the vaginal epithelium longitudinally, with their tips directed upward to bluntly and sharply dissect the fibromuscular tissue from the overlying vaginal epithelium. The scissors are then used to cut a midline longitudinal incision (**FIG. 32.9**). A single midline incision (eg, without the inverse T/longitudinal incision at the perineal body) will prevent unintended narrowing of the genital hiatus, possibly contributing to dyspareunia. Sequential Allis-Adair clamps (T clamps, Pratt clamps) are placed close together along the edges of the cut vaginal epithelium.

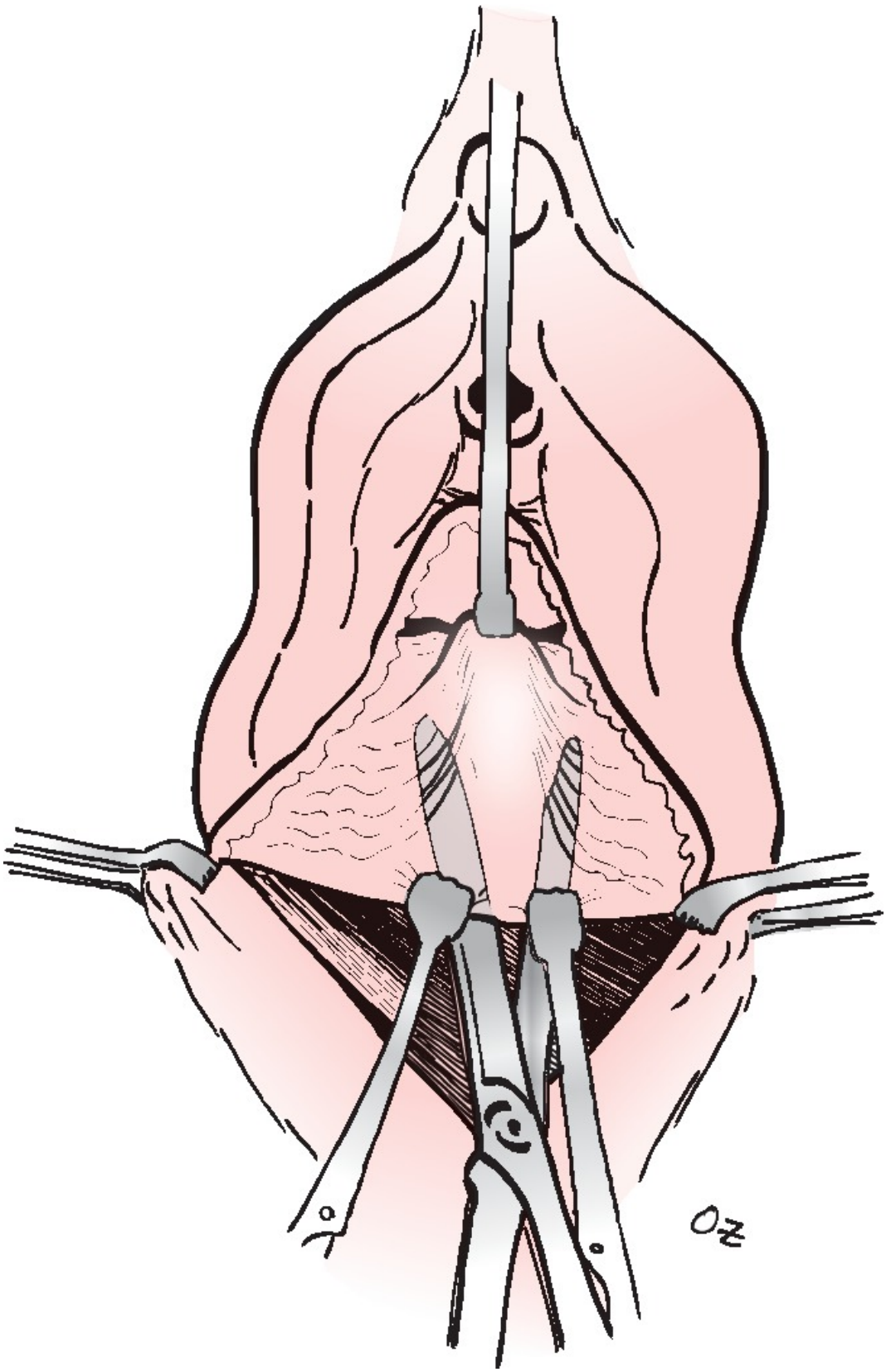


**FIGURE 32.9** Posterior colporrhaphy: Mayo scissors with their tips up are used to start the dissection of the vaginal epithelium from the underlying fibromuscular tissue.

Next, the fibromuscular tissue is dissected off the overlying vaginal epithelium with Metzenbaum scissors, taking care to leave the vaginal epithelium as thin as possible. Blood vessels should be dissected off the vaginal epithelium, that is, vessels should "stay" with the fibromuscular layer. Occasionally, cautery is needed to control bleeding from small perforating vessels. Bleeding may indicate that the surgeon is "splitting a surgical plane," as it is common to encounter fibrosis from prior obstetrical injury and repair or previous pelvic reconstructive surgery. If the dissection proceeds too easily, the surgical plane may be too deep, under the posterior rectovaginal fibromuscular tissue. By staying in a superficial plane, and even "splitting the surgical plane," the surgeon will minimize potential injury to the rectum and will leave the strongest fibromuscular tissue to be incorporated into the repair.

One way to achieve the correct depth of dissection is to start with the scissors perpendicular to the vaginal epithelium and as close to the Allis-Adair clamp as possible (**FIG. 32.10**). While grasping the Allis-Adair clamp in the palm of the hand, the ball pad of the index finger is placed behind the elevated vaginal mucosa, at the junction of the vaginal epithelium and fibromuscular tissue. While gently tenting up the index finger, the Metzenbaum scissors are placed first perpendicularly to the vaginal epithelium as close to the Allis-Adair clamp as possible to help achieve the correct depth of dissection. This is then followed by placing the Metzenbaum scissors at an acute angle to the vaginal epithelium, and the fibromuscular tissue is dissected off while applying gentle pressure toward the vaginal epithelium. It is helpful for the assistant to use a smooth forceps such as Russians to apply countertraction to elevate the fibromuscular tissue in a perpendicular direction from the underlying

vaginal epithelium. Often, a weblike white appearance of tissue planes is seen, and this can be followed to complete the dissection.

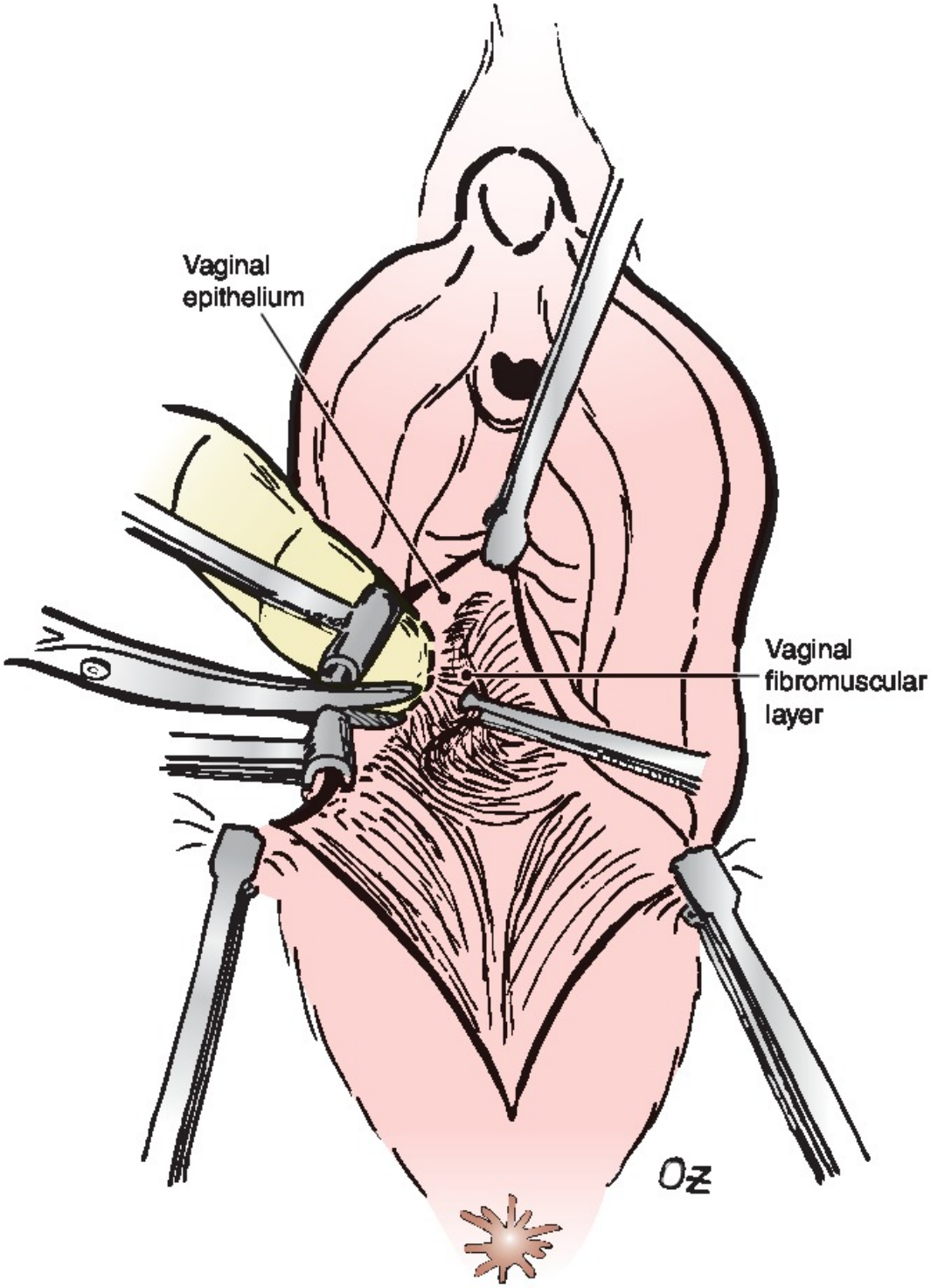


**FIGURE 32.10** Posterior colporrhaphy: Metzenbaum scissors are used to dissect the underlying fibromuscular tissue off of the vaginal epithelium. This plane is identified with the help of traction on the Allis-Adair clamps and with the surgeon's finger behind the vaginal epithelium.

The dissection is then carried out superiorly to the noted proximal aspect of the prolapse and laterally to the pelvic sidewalls, where the fibromuscular tissue attaches to the arcus tendineus fascia rectovaginalis (ie, pelvic sidewall). The levator ani muscles may be visualized just medial to this attachment and should not be transected.

Next, the posterior support defect is reduced surgically with interrupted sutures. This is done by reapproximating the most proximal, strong fibromuscular tissue to the most proximal extent of the dissection and then transversely plicating the fibromuscular tissue using a delayed absorbable suture of choice (**FIG. 32.11**). Intermittent digital rectal examinations are performed to ensure that sutures are not being placed into the rectum and to assure that the plication of fibromuscular tissue is sufficient to reduce the posterior vaginal wall defect. Also, care is taken to place each suture in continuity with the previous suture to prevent a stricture or banding of the posterior vaginal wall, which could potentially lead to dyspareunia. Once the posterior vaginal wall defect is satisfactorily reduced, the vaginal epithelium is trimmed only if necessary (ie, to excise very redundant vaginal epithelium from a large prolapse or crush marks from the Allis clamps) (**FIG. 32.12**). The epithelium is then reapproximated with running, locked 2-0 absorbable braided suture to the hymen. The suture is held while the perineorrhaphy is completed. A running locked or interrupted suture is preferred as these techniques prevent bunching and shortening of the vagina and also provide hemostasis. A running locked suture is typically

preferred over interrupted sutures due to efficiency and speed. After the epithelium is reapproximated, the caliber of the vagina should be checked and ideally allow easy passage of two to three fingerbreadths.

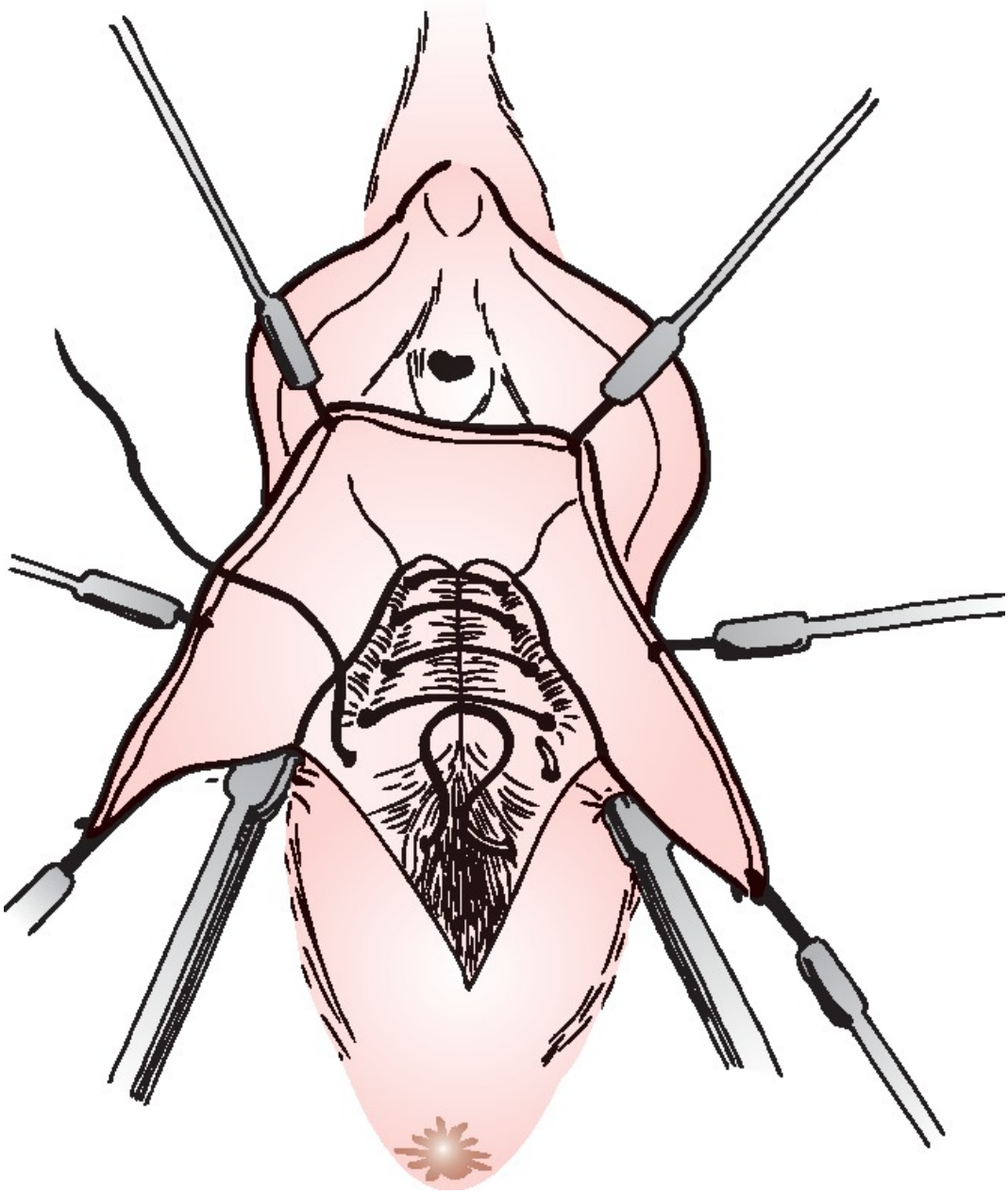


**FIGURE 32.11** Posterior colporrhaphy: midline plication. The fibromuscular tissue is

plicated transversely with interrupted sutures.

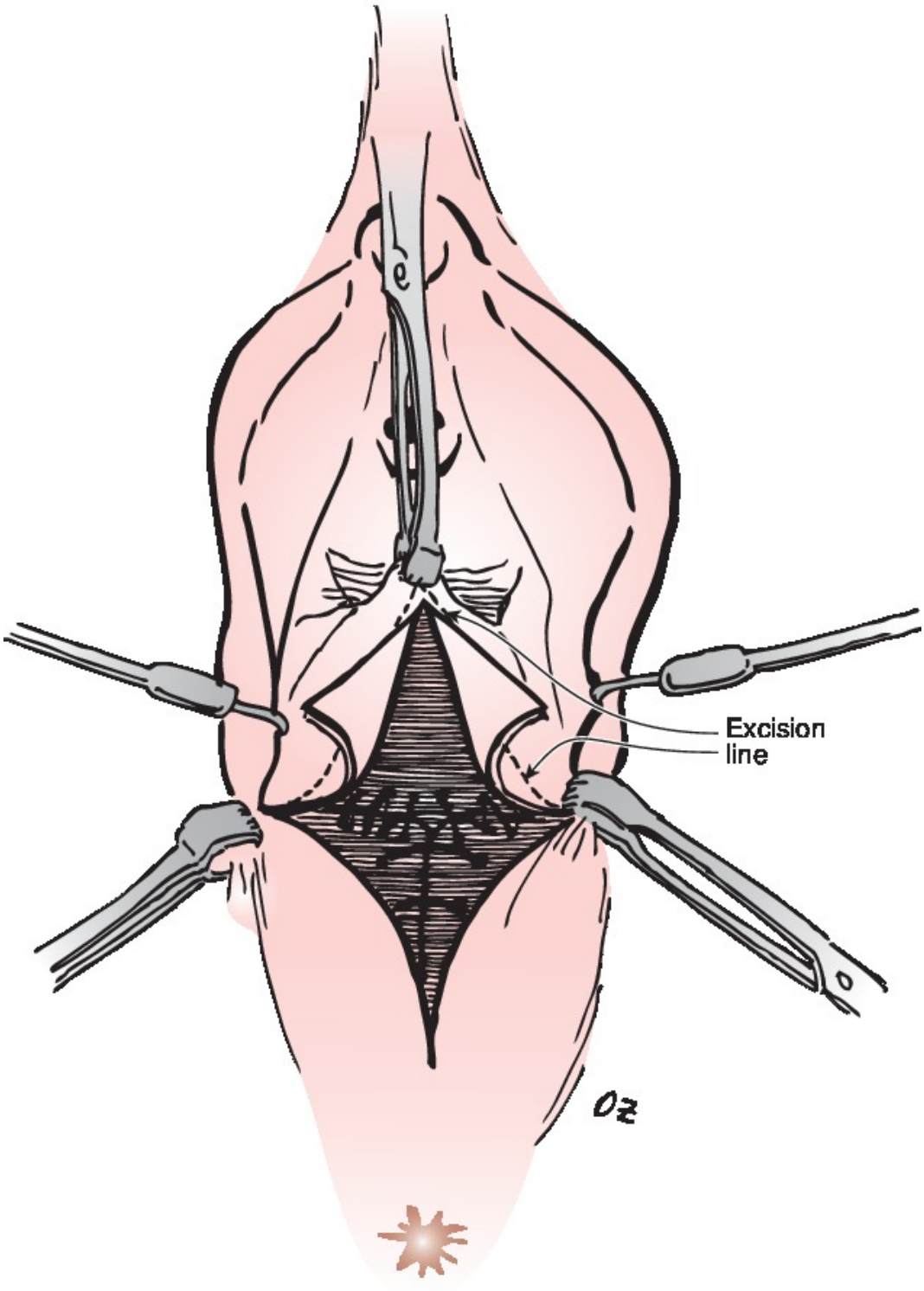
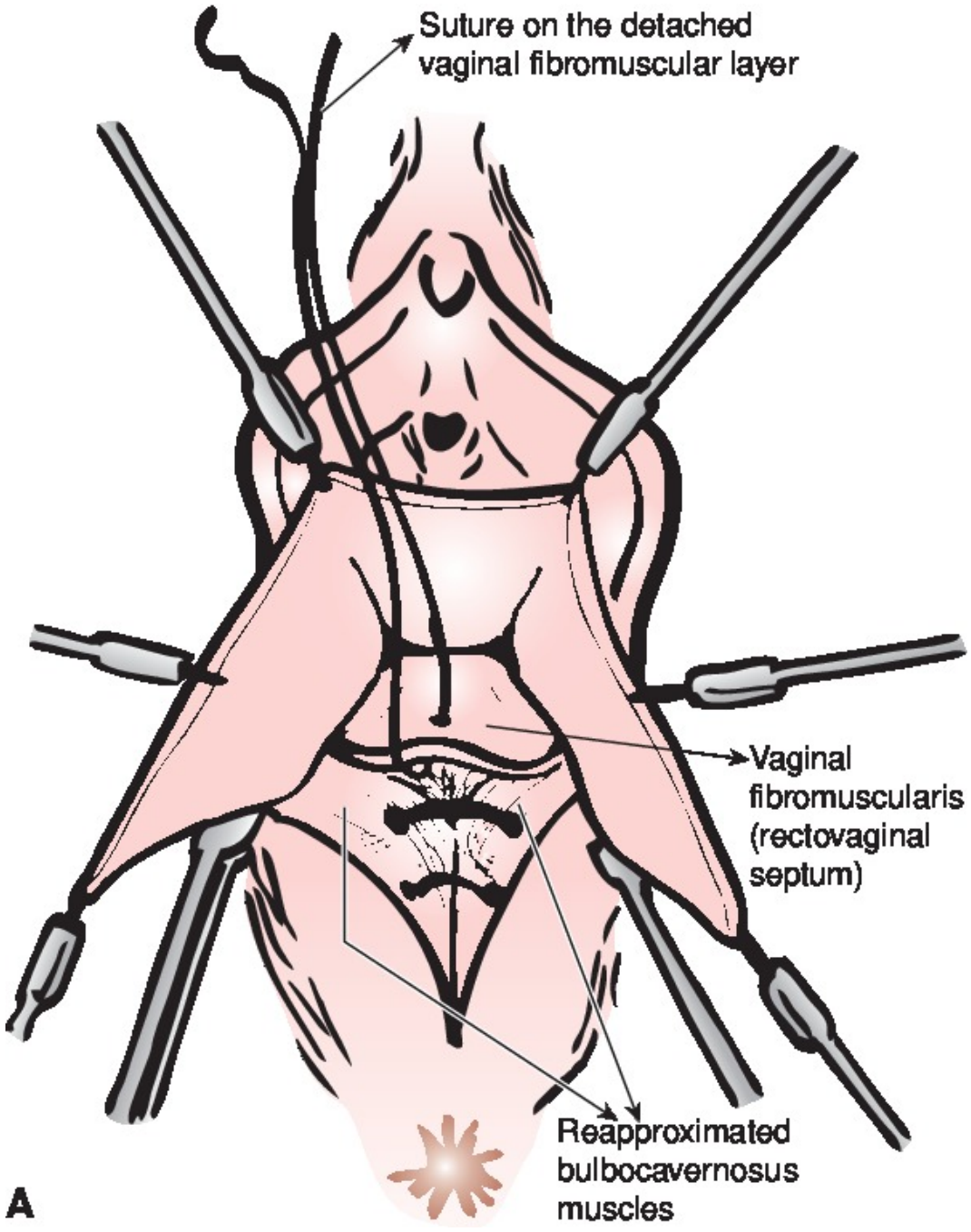


**FIGURE 32.12** Posterior colporrhaphy: before the closure of the vaginal epithelium, its edges may be trimmed slightly as needed.

To complete the perineorrhaphy, a series of wide interrupted 2-0 delayed absorbable monofilament sutures on a CT-1 needle are placed, to include a portion of superficial transverse perineal muscle and bulbocavernosus muscles (**FIG. 32.13**). The goal is to join the muscles in the midline and rebuild the perineal body. Deep sutures are placed first in a horizontal direction (ie, parallel to the vagina) (crown stitch) and then in a vertical direction (ie, perpendicular to the vagina and rectum). Then a 2-0 absorbable braided suture is placed over these sutures superficially in a vertical direction to reinforce the repair and reapproximate the vaginal epithelium. These sutures are held with snaps. Absorbable braided suture is used closer to the perineal skin as it is less palpable than a monofilament and, therefore, less uncomfortable for the patient in the postoperative period. After all three sutures are placed, good placement can be confirmed by a tug on the sutures; the bulbocavernosus and transverse perineal muscles should appear to be pulled into the reconstructed perineal body. At this stage, interrupted 2-0 delayed absorbable monofilament sutures can be placed to reapproximate the fibromuscular tissue to the perineal body. The perineorrhaphy sutures are then tied from proximal to distal, and the genital hiatus and caliber is checked to be at least two to three fingerbreadths. A rectal examination is performed to assure rectal integrity. Attention is then turned back to the running locked 2-0 absorbable braided suture that was used to close the vaginal epithelium, and this can be used in a running fashion to reapproximate the epithelial edges distal to the hymen.


Suture on the detached vaginal fibromuscular layer
Vaginal fibromuscularis (rectovaginal septum)
Reapproximated bulbocavernosus muscles
A

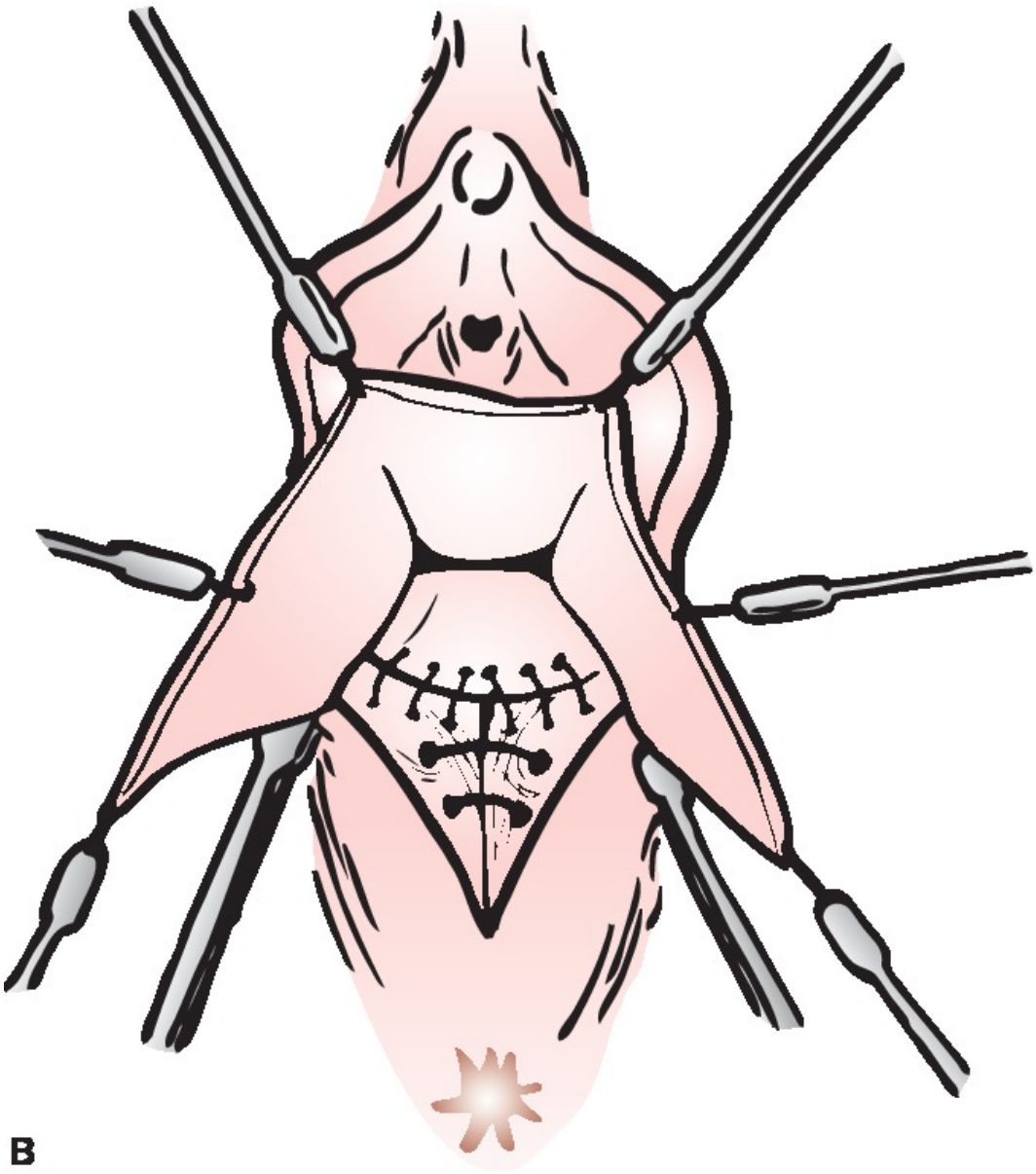



**FIGURE 32.13** **A.** The bulbocavernosus muscles have been reapproximated to rebuild the perineal body, and the detached edge of the vaginal fibromusclar layer is sutured to the restored perineal body. **B.** The vaginal fibromuscular layer has been sutured to the

perineal body with approximately four to six stitches.

Of note, a levator plication is not typically performed in sexually active women, as studies have demonstrated an increase in dyspareunia and immediate postoperative pain due to constriction of the vaginal caliber with this approach. In women who do not desire future sexual activity, a levator plication may be an appropriate complement to a posterior colporrhaphy. During the transverse plication of the fibromuscular tissue, 2-0 delayed absorbable monofilament sutures can be placed into the lateral levator ani muscles and tied in the midline to create a muscular shelf.

Traditional posterior colporrhaphy demonstrates success rates of 76%-96% at 1 year. About 70% of patients have improvement in obstructed defecation symptoms (specifically splinting and incomplete emptying).

## *Site-Specific Repair*

On digital rectal examination, if a more focused/discrete defect is palpated in the fibromuscular tissue, then a site-specific defect repair can be performed. Advantages to this repair may include less narrowing of the vaginal caliber.

This procedure is started in a similar fashion as the traditional midline plication and can be performed with or without a perineorrhaphy. After the vaginal epithelium is opened in the midline and the dissection carried proximally to the posterior compartment bulge and laterally to the pelvic sidewalls/levator muscles, a digital rectal examination is performed to identify a specific “tear” (separation or focal weakness) in the rectovaginal fibromuscularis. Such focal defects have been identified in the lateral, distal, midline, or superior portion of the tissue (**FIG. 32.14**). They will be revealed by easy placement of the rectal finger into a pocket through the visible fibromuscular tissue. At this stage, instead of performing a series of transverse interrupted plication sutures as described above, sutures are placed to reapproximate the edges of the fibromuscular

tissue adjacent to the identified defect. Reduction of prolapse is evaluated with a digital rectal examination. The vaginal epithelium is reapproximated, and a perineorrhaphy is performed if needed as described above.

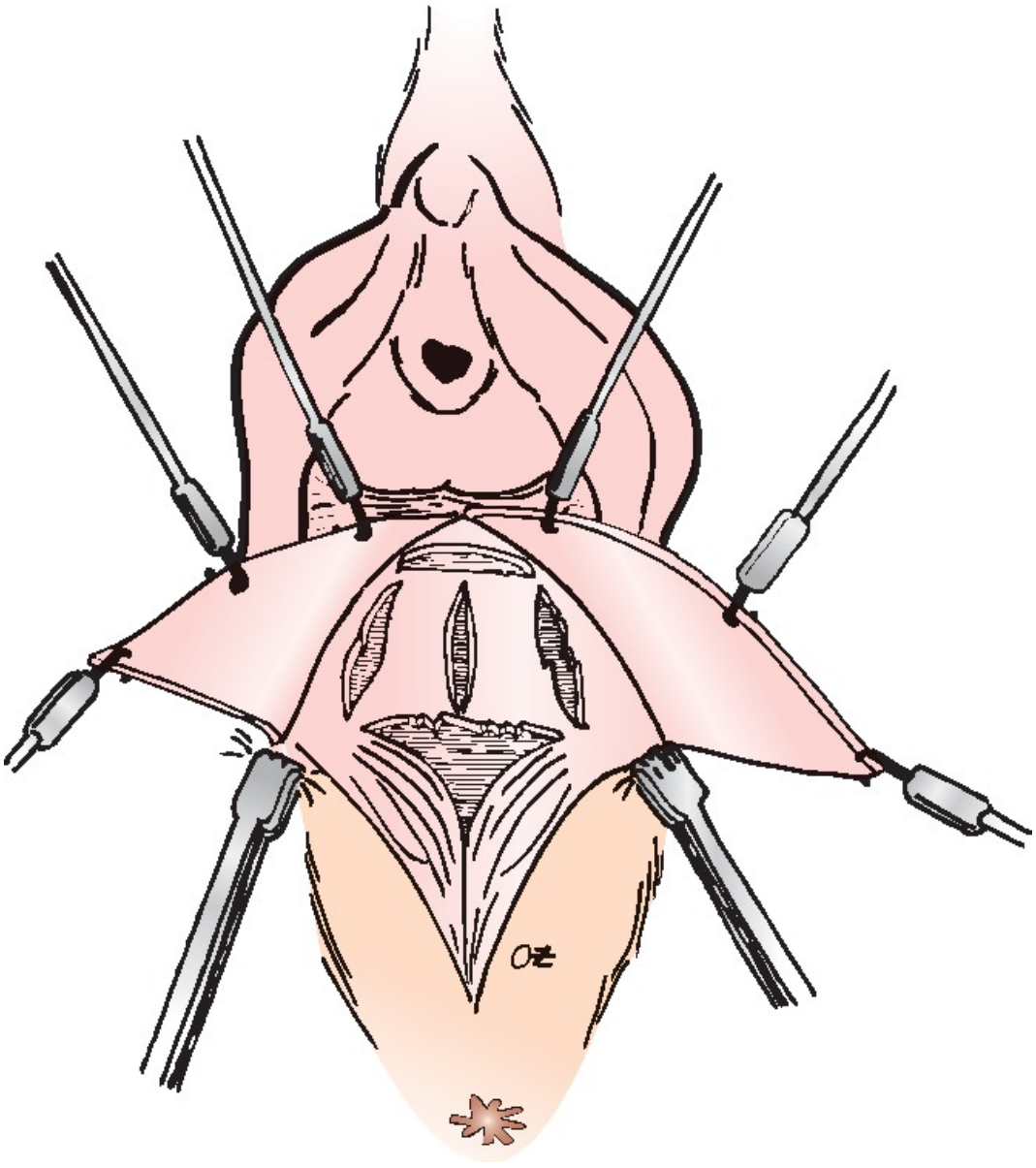


**FIGURE 32.14** The formation of rectocele may result from discrete tears occurring in the

rectovaginal fascia at various points along the posterior vagina.

Site-specific posterior vaginal wall repair demonstrates an anatomic success rate ranging from 56% to 100%. About 18% of patients have improvement in splinting symptoms (**BOX 32.2**).

## BOX 32.2 STEPS IN THE PROCEDURE

### Posterior Compartment Repair

*Posterior Colporrhaphy (Midline Plication or Site-Specific Repair) +/− Perineorrhaphy*

1. Use Allis clamps to delineate the area of dissection on the vaginal mucosa (proximal and distal ends of the prolapse).
2. Inject vasopressin for hemostasis and hydrodissection.
3. Incise vaginal epithelium.
4. Dissect the fibromuscular tissue off the overlying vaginal epithelium.
5. Reduce the posterior defect with sutures. This can be done by transverse plication (**traditional midline posterior colporrhaphy**) or by focused suture placement (**site-specific**).
6. Trim excess vaginal epithelium as needed.
7. Reapproximate the edges of the vaginal epithelium with absorbable suture.
8. Complete the **perineorrhaphy** with three wide interrupted sutures to include the superficial and deep transverse perineal muscles and bulbocavernosus muscles to join them in the midline and rebuild the perineal body.
9. Check vaginal caliber with a digital vaginal examination and rectal integrity with a digital rectal examination.

## *Transanal Approach*

Occasionally, colorectal surgeons will approach a posterior compartment procedure through a transanal approach. This is usually done with the patient in the prone jackknife position. Existing systematic reviews demonstrated a higher recurrence rate with the transanal approach compared to the vaginal approach (higher prolapse symptoms, higher recurrence on clinical examination, and larger mean depth of rectocele on defecography) as well as greater blood loss and use of pain medication. Therefore, the transanal approach is not recommended.

## *Vaginal Approach, Graft Augmented*

There are very few data supporting transvaginal graft use in the posterior compartment and some data suggesting that it increases adverse events including dyspareunia. However, there are rare instances where the posterior vaginal wall is severely attenuated and cannot be corrected with a native tissue repair alone. These women should be referred to a female pelvic medicine and reconstructive surgeon who can counsel them on the risks and benefits of graft in the posterior compartment.

## *Sacrocolpoperineopexy*

If a sacrocolpopexy is being performed to correct a coexisting apical prolapse, this procedure may be extended to correct a distal posterior vaginal wall prolapse. This procedure is called sacrocolpoperineopexy. To accomplish this, the posterior sacrocolpopexy graft arm is extended down to the perineal body, with a goal of addressing posterior level 1-3 support. This procedure requires complete dissection of the rectovaginal space to the perineal body. In many cases, a perineorrhaphy is also performed to restore level 3 support.

# ENTEROCELE REPAIR

Enterocele repairs, including Moschowitz, Halban, and McCall culdoplasty, are performed to prevent/treat enteroceles, support the

posterior vaginal apex, and close the cul-de-sac. These may be performed at the time of hysterectomy. However, there are few evidence-based data available to support that these procedures effectively treat enterocele. Often, significant apical prolapse coexists with an enterocele, and thus an apical support procedure is preferred. Thus, enterocele repairs should be reserved for treatment of isolated enterocele (eg, with good apical support).

# Vaginal Enterocele Repairs

## *McCall Culdoplasty*

A McCall culdoplasty is usually performed at the time of vaginal hysterectomy. A true McCall culdoplasty is a preventative procedure, though there are modifications (most notably the Modified Mayo McCall's) that can be used to address an enterocele in the setting of apical prolapse (see Chapter 30).

## *Vaginal Repair of Enterocele*

In a true isolated enterocele, that is, a prolapse of abdominal viscera (small bowel or sigmoid) into a space between the rectum and a well-supported vaginal apex, a simple vaginal approach can be performed. Intraoperatively, the enterocele is located visually and with digital rectal examination (to confirm that the observed bulge is not a rectocele). A longitudinal incision is made in the vagina overlying the observed defect, and the underlying fibromuscular tissue is carefully dissected until the sac of the enterocele is encountered. The peritoneal sac is grasped with an Allis clamp, and the sac is mobilized from the perirectal fibromuscular tissue. A small incision is made in the peritoneal sac, and a finger is placed into the sac. This finger allows for delineation of the defect and acts as a physical barrier to protect the intra-abdominal contents (bowel) from being incorporated into the repair. A purse-string suture is placed at the proximal neck of the sac, followed by one to two more purse-string sutures. With a finger in place to reduce the intra-abdominal contents, the proximal purse-string suture is tied, followed by the

distal suture(s). Next, the remaining peritoneum (distal to the sutures) is ligated. The closure and ligation of the peritoneal sac is followed by two to three sutures that are placed first through the lateral anterior rectal wall, the posterior apical vaginal wall, and the uterosacral ligaments. These sutures should not enter the lumen of either the rectum or the vagina. These are then successively tied down to further obliterate the enterocele. The vaginal mucosa is closed in the usual interrupted fashion, and/or a concomitant posterior colporrhaphy is performed.

# Abdominal Enterocele Repairs

Prevention/repair of enterocele can also be approached abdominally via an open or minimally invasive approach. These can be performed at the same time as a hysterectomy or other prolapse procedure. There is scant evidence to support the benefit of these procedures alone or as an adjunct to procedures to address apical prolapse. Thus, there is a very limited role for these procedures in contemporary practice.

The goal of both the Moschowitz and Halban culdoplasties is to obliterate the posterior cul-de-sac by suturing the posterior vagina to the anterior sigmoid. For both of these procedures, the cul-de-sac is exposed with retraction, and both ureters should be visualized. Rectal deviation with transanal insertion of an end to end anastomosis sizer (EEA) may be useful.

For a Halban culdoplasty, sutures are placed in a longitudinal fashion. A series of interrupted sutures are placed in running fashion, beginning distally in the posterior vaginal wall and then returning proximally along the rectosigmoid. Usually, three to four sutures will obliterate the space medial to the uterosacral ligaments. Some surgeons will place suture in each uterosacral ligament to shorten them. After all sutures are placed, they are tied down to approximate the posterior vagina to the rectosigmoid.

The Moschowitz culdoplasty is similar, although concentric purse-string sutures are utilized. These begin at one uterosacral ligament, heading across the posterior vaginal wall, through the

other uterosacral ligament, and then returning across the anterior rectosigmoid. Usually, two to three sutures are placed.

Because of the potential to kink the ureters, cystoscopy must be performed to ensure ureteral patency.

# POSTOPERATIVE CARE

Often a vaginal packing with bacitracin ointment is left in place for several hours after surgery. If a packing is left in place, a Foley catheter is also left in place. Both of these are removed prior to discharge. Patients can generally be discharged the same day and must follow a strict bowel regimen to keep stool consistency soft. Telephone follow-up is recommended to ensure adequate ambulation and regular diet, to screen for constipation and/or voiding difficulties, and to discuss weaning off of narcotics and maintenance of bowel regimen with addition of laxatives if needed.

Overall, serious intra- or perioperative complications for repairs of the anterior and posterior vaginal wall prolapse are rare. Intraoperatively, there is a risk of bleeding and need for blood transfusion (this is most common in paravaginal repairs due to the robust blood supply), ureteral kinking and bladder, ureteral, or rectal injury. In these scenarios, the complications can be immediately managed if recognized.

The most common postoperative complications include transient urinary retention, urinary tract infection, constipation, and pain. Uncommon serious complications can include wound infection, hematoma/bleeding, or injury to the rectum, bladder, or ureters. There have been reports of vesicovaginal or rectovaginal fistula development, though this is extremely rare. Further, *de novo* symptoms including *de novo* dyspareunia, stress incontinence, overactive bladder, and fecal incontinence can occur.

# OUTCOMES

It may be difficult to compare published outcomes of prolapse procedures due to heterogeneity in surgical technique and variability

in the definition of outcomes. For example, many contemporary studies define surgical success as support of the vaginal wall with no descent beyond the hymen. The rationale for this definition of surgical success is that prolapse beyond the hymenal threshold is associated with symptomatic prolapse. Other studies use more strict definitions of surgical success, such as prolapse stage 0-1. Yet other studies use composite definitions of success, such as the absence of bulge symptoms, no prolapse beyond the hymen, and without retreatment or reoperation.

Data from case series suggest that success rates for traditional anterior colporrhaphy range from 37% to 83% while site-specific and traditional posterior colporrhaphy success rates range from 56% to 100%. There are some randomized controlled trials comparing specific surgical techniques, including traditional posterior colporrhaphy vs site-specific repair and/or graft augmentation. In a three-armed randomized controlled trial comparing traditional posterior colporrhaphy to site-specific repair to graft augmentation with a porcine-derived, acellular collagen matrix graft (Fortagen), superior anatomic and functional outcomes were demonstrated for both the traditional posterior colporrhaphy and site-specific repair groups compared to the graft augmentation group. All three groups demonstrated improved defecatory, sexual, and quality of life measures.

Systematic reviews have examined traditional anterior colporrhaphy vs mesh augmentation, transvaginal vs transanal approach to posterior vaginal wall repair, and the STARR technique. Overall, symptoms and anatomy improved in all surgical procedures. Most of the comparative trials for anterior prolapse failed to demonstrate significant differences in anatomic and subjective outcomes between surgical approaches. A review by Maher et al. concluded that compared to anterior native vaginal repair, biologic grafts provide minimal advantages. Conversely, this review found that permanent mesh resulted in improved outcomes with regard to awareness of prolapse, recurrent anterior prolapse, and repeat surgery for prolapse.

For posterior vaginal prolapse, traditional posterior colporrhaphy has demonstrated better anatomic outcomes compared to site-

specific posterior repairs. However, a review by Grimes et al. found that both posterior vaginal wall site-specific defect repair and traditional native-tissue posterior colporrhaphy almost universally improved both anatomic outcomes of prolapse, as well as obstructive defecatory symptoms. Data does not support the use of synthetic mesh or biologic graft in the posterior compartment.

# KEY POINTS

## ANTERIOR

- Anterior vaginal wall prolapse is usually associated with apical prolapse and requires a concomitant apical procedure. It is, therefore, unusual to perform an isolated anterior compartment repair.
- Anterior vaginal wall prolapse may be associated with symptoms including voiding dysfunction, splinting to void, urinary retention, and occult stress incontinence, though these urinary symptoms are multifactorial and may not completely resolve with repair of anterior vaginal wall prolapse.
- Native tissue repair of anterior vaginal wall defects is moderately anatomically successful. Success rates for reducing bulge symptoms range from 37% to 83%.
- Cystoscopy should be performed after anterior compartment prolapse to ensure ureteral and bladder integrity.
- Graft/mesh has minimal advantage compared to native tissue repair with increased morbidity. However, native tissue repair is more likely than mesh-reinforced repair to be associated with persistence of bulge/protrusion symptoms after surgery, recurrence of anterior compartment prolapse, and increased risk of repeat surgery. It is associated with lower risk of *de novo* SUI and lower incidence of bladder injury.

## POSTERIOR

- Posterior vaginal wall is often associated with symptoms of defecatory dysfunction/obstructed defecation, including splinting, straining, manual evacuation, and incomplete emptying. However, these defecatory symptoms are multifactorial and may not completely resolve with repair of posterior vaginal wall prolapse.
- Native tissue repair of posterior vaginal wall defects is anatomically successful. Success rates for reducing bulge range from 56% to 100%.
- Most posterior vaginal compartment repairs benefit from the addition of a perineorrhaphy (rebuilding level 3 support/perineal body).
- After posterior colporrhaphy, 70% of patients have improvement in obstructed defecation symptoms
- In the posterior compartment, graft augmentation does not improve anatomic outcomes of posterior vaginal wall repair.
- Transvaginal posterior vaginal wall repair is superior to transanal approach.
- Rectal examination prior to, during, and before vaginal closure is critical for identification of the defects and confirmation of restoration of normal anatomy.

### BOTH

- It is important to evaluate the vaginal apex while determining management for anterior and posterior vaginal wall prolapse. Apical suspension is usually needed at time of anterior vaginal wall repair and often needed at time of posterior vaginal wall prolapse.

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# CHAPTER 33

# MIDURETHRAL SLINGS AND SURGERY FOR STRESS URINARY INCONTINENCE

Renée M. Ward

**Pathophysiology**
**Initial Evaluation**
History
Physical Examination
Additional Evaluation of SUI
**Nonsurgical Treatment of SUI**
**Surgical Treatment of SUI**
Retropubic Midurethral Sling Procedures
Transobturator Midurethral Sling
Complications From Midurethral Slings
Burch Retropubic Urethropexy
Pubovaginal Sling
Urethral Bulking Agents
**Surgical Treatment of Mixed Urinary Incontinence**
**Occult SUI**

Stress urinary incontinence (SUI) is defined as the involuntary loss of urine on effort or physical exertion, such as coughing, laughing, or sneezing, which is bothersome to the patient. It is confirmed objectively by observing leakage during cough or Valsalva. It is more prevalent with age. By age 80, a patient's cumulative risk of undergoing surgery for SUI is 13.6%, with an annual risk of 3.8 per 1000 women. Both surgical treatment and the prevalence of disease follow a bimodal pattern, peaking in the mid-40s and at 70 years of age. Only about 25% of patients with urinary incontinence seek medical care. This highlights the importance of screening for incontinence and educating patients with affirmative responses that, although common, leakage is not normal and excellent treatments are available.

# PATHOPHYSIOLOGY

The pathophysiology of female SUI is complex, and as of yet, still not completely understood. There are multiple factors involved in the mechanism of stress continence, including urethral function, urethrovaginal support, and the degree of pressure on the bladder during provocative maneuvers (the strength of Valsalva or a cough on vesicular pressure). Of these, urethral function, specifically maximal urethral closure pressure, has been shown to be most strongly associated with SUI.

Many contemporary treatments, however, are focused on urethrovaginal support. The female urethra lies on a supportive layer composed of endopelvic fascia and the anterior vaginal wall. Additional support is obtained via lateral attachments to the arcus tendineus fascia pelvis and the levator ani muscles. Increased abdominal pressure, such as during a cough, compresses the urethra against this hammock of support, allowing continence to be maintained. The importance of the midurethral complex was emphasized with Petros and Ulmsten's integral theory, which has led to the development of midurethral slings. Midurethral sling surgery has dramatically changed how we treat SUI due to its minimally invasive approach, low rate of morbidity, and high rates of success.

The term “intrinsic sphincter deficiency” has been used to describe an SUI subtype. This term was initially coined by McGuire in the 1980s. Since then, this term has been associated with multiple, and sometimes contradictory, descriptions. Some use the term to describe type III urinary incontinence, which refers to SUI in the absence of significant urethrovesical hypermobility. Others use the term to describe a low-pressure urethra with a maximum urethral closure pressure <20 cm water or an abdominal leak point pressure <60 cm water, irrespective of mobility. A third classification scheme describes intrinsic sphincter deficiency as an “open” bladder neck at rest, which may be documented during cystoscopy or a video urodynamic evaluation (**FIG. 33.1**). Finally, a fourth use of the term refers simply to severe SUI, noted either from severe subjective symptoms or objectively due to leakage at very low bladder volumes. Historically, these myriad definitions have been used to stratify patients according to which surgical therapies were most suitable. With the advent of tension-free midurethral slings, which have high success rates even for many of these previously hard to treat populations, the term has become less clinically relevant. The continued use of this term may be attributed, in part, to hospital reimbursement, billing, and coding.

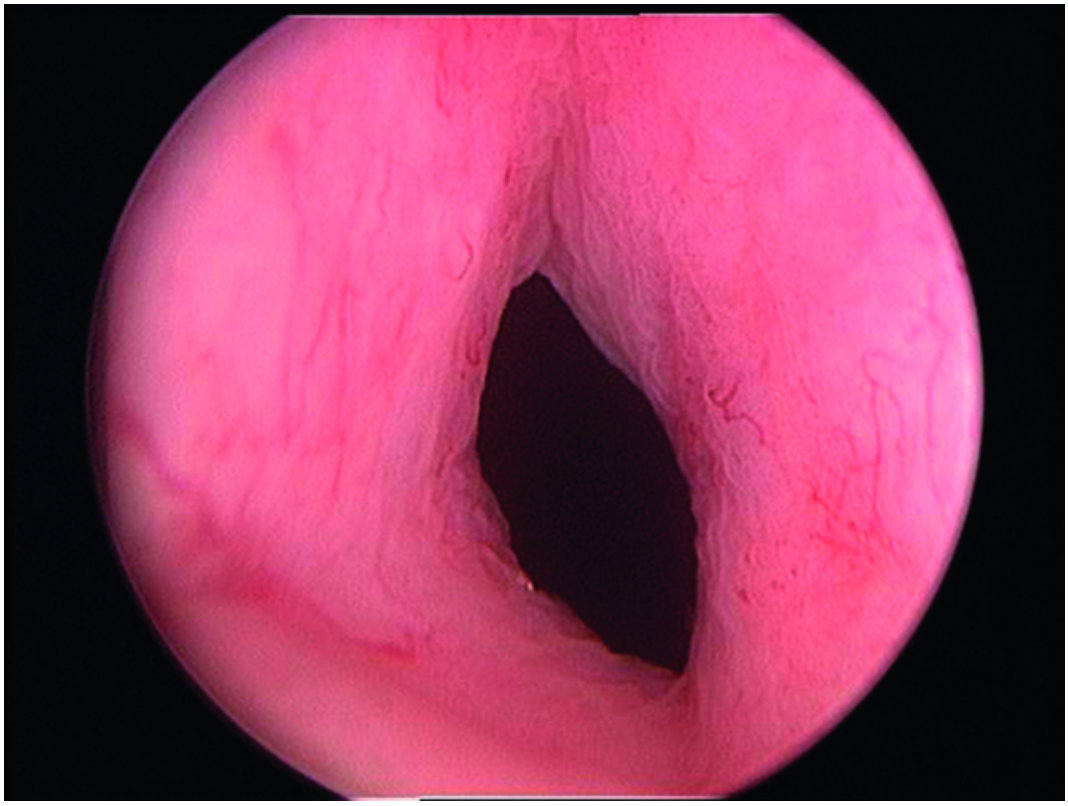

**FIGURE 33.1** Photograph from urethroscopy, illustrating a functionless urethra. The bladder neck is passively open at rest. In a patient with stress incontinence, this appearance may signify intrinsic sphincter deficiency. (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and Pelvic Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

# INITIAL EVALUATION

## History

Given that urinary incontinence is a sensitive and highly personal issue, it is imperative that the history is obtained in a comfortable environment where the patient feels safe and respected. Descriptions of leaking with a cough, sneeze, or high-impact physical activity suggest SUI, but other more nuanced complaints may also be present. Leakage with twisting, heavy lifting, climbing stairs, or even upon standing can suggest SUI if it is not preceded by sensory urgency. In fact, such associations may indicate severe SUI. When there are complaints of mixed urinary incontinence (both SUI and urgency urinary incontinence), it is helpful to determine if one component is predominant. A voiding diary can be helpful. Urinary retention may also contribute to incontinence during stress provocative maneuvers but is managed differently.

It is important to assess how the incontinence affects the patient's quality of life. When not bothersome, SUI does not require therapy; however, when leakage contributes to a reduced activity level, decreased participation in social outings, or embarrassment, therapy is warranted. Although common and prevalent, incontinence is not normal, and patients should be counseled that effective conservative and surgical treatments are available.

During the history, review medications and take note of those that may impact the autonomic nervous system. Inquire about prior therapies and surgeries for bladder, pelvic, and bowel disorders. Ideally, operative reports from prior pelvic surgery are obtained and reviewed. This is particularly important if the prior surgery used a permanent implant or mesh.

# Physical Examination

The physical assessment includes a screening evaluation for neurologic deficits. Neurogenic bladder is comprised of a unique set of disorders, and while they can copresent with SUI, this typically should be managed by a specialist. On the abdominal examination, ensure that there are no masses or ascites, as an extrinsic process could exacerbate SUI.

Providers accustomed to performing a general gynecologic examination will not have difficulty adding the components needed to

assess urinary incontinence. One streamlined approach to this evaluation is to have the patient void prior to getting undressed. Once in lithotomy position, an empty supine cough stress test can be performed, followed by evaluation of the postvoid residual via catheterization or a bladder scan. (If there is no objective confirmation of SUI at this visit, then a full-bladder cough stress test may be performed in the future, especially if initial conservative therapies are unsuccessful.) Urethral mobility is assessed with a lubricated sterile cotton swab, placed in the urethra. As the patient strains or coughs, the angle formed by the cotton swab with respect to the horizontal is measured. Hypermobility is defined as an excursion of 30° or more from the horizontal during straining (**FIG. 33.2**). Alternatively, mobility can be measured by placing the sterile wooden aspect of the cotton swab down the urethral catheter while it is still in the urethra following the catheterization. This minimizes discomfort from the cotton swab test but is associated with a slight reduction in the degrees of excursion.

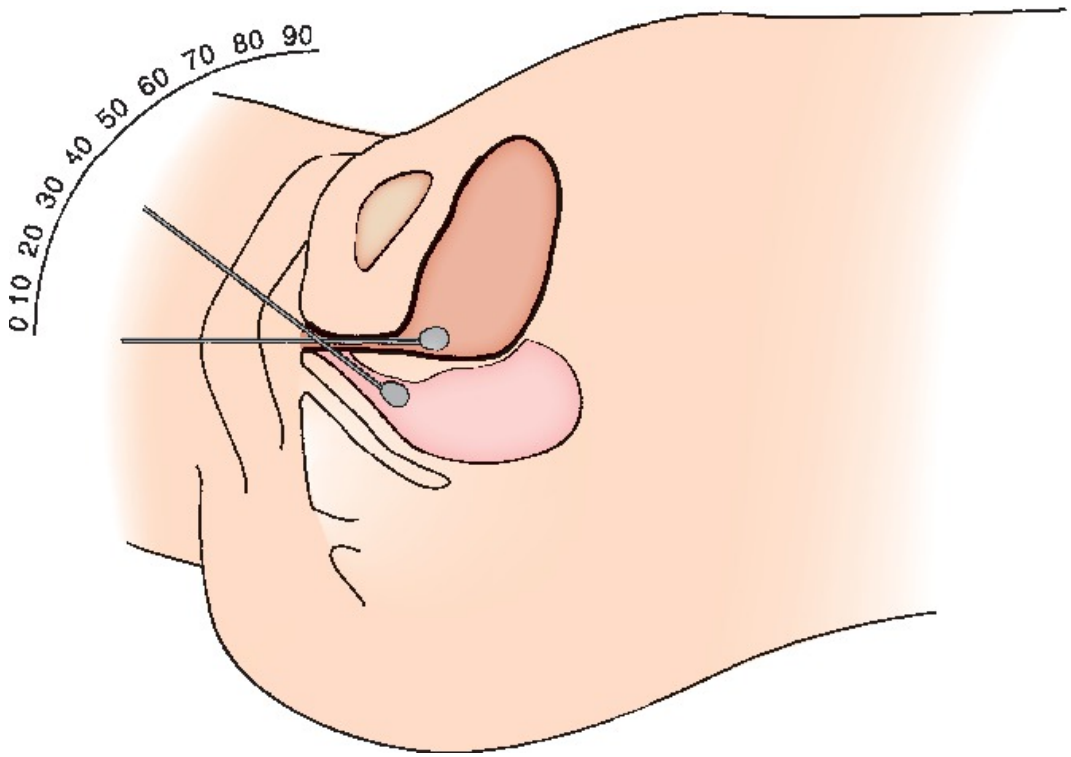

**FIGURE 33.2** The cotton swab test demonstrates a resting angle close to 0° and a straining angle of ~40°. A straining angle >30° above the horizontal is considered "hypermobile." (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and Pelvic Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

The urethra is examined for a potential urethral diverticulum, although unless inflamed or large, a diverticulum may be difficult to detect on pelvic examination. If a diverticulum is suspected, milky fluid can often be expressed from the urethra. If infected, the diverticulum will be tender. Although diverticula are not common, their preoperative identification will change the treatment plan. When suspected, further evaluation with a pelvic MRI, double-balloon positive pressure urethrogram, or cystourethroscopy is indicated.

As with any good gynecologic history and examination, attention is paid toward all of the major organs in the pelvis: urinary, genital, and lower gastrointestinal tracts. The vulva and urethra should also be examined. Severe incontinence may lead to skin breakdown and vulvitis. Other pelvic dysfunction and pathology, such as a large fibroid, pelvic mass, or severe constipation, may impact urinary function. For example, a large fibroid uterus may contribute to urinary frequency. Significant uterovaginal prolapse (to or beyond the hymen) may impact bladder function, potentially contributing to voiding dysfunction.

# Additional Evaluation of SUI

Few laboratory studies are needed when assessing urinary incontinence. A urinalysis assesses for pyuria and hematuria.

Dipstick hematuria should be evaluated with microscopy and a urine culture, with subsequent evaluation as merited by the findings. When indicated, urine culture assesses for infection. Some patients will only have SUI during a urinary tract infection, and when treated, their symptoms will resolve.

A voiding diary may be useful. The patient is instructed to record the volume of oral liquid intake and volume of urine output for a period of 2 or more days. Each entry records a new timed event: fluid consumed, a void, or an incontinence event. Next to each incontinence event, record whether it was preceded by urgency and what activity was being done when it occurred. The diary may be helpful for distinguishing urgency and stress events, whether polyuria is present, volume of caffeinated beverages consumed, and the frequency and volume of voids. This not only helps guide the provider but often gives insight to the patient about drinking and voiding habits as well.

The goals of a urodynamic evaluation are to confirm the diagnosis of SUI, exclude conditions that could impact the success of therapy, and identify any increased risk for adverse outcomes, such as retention. A urodynamic evaluation is rarely necessary prior to conservative treatment of SUI. Even for those desiring surgical management, multichannel urodynamic evaluation is often not needed. A randomized trial by Nager and colleagues found that many women with uncomplicated, objectively confirmed SUI were unlikely to benefit from a complex urodynamic evaluation. The study included women with SUI or stress predominant mixed urinary incontinence, stage II or less pelvic organ prolapse, no prior incontinence surgery, a postvoid residual <150 mL, and urethral hypermobility (**TABLE 33.1**). The basic office evaluation, applied to all patients, included assessment of the above parameters, a urinalysis or culture, and a provocative (cough or Valsalva) stress test at any bladder volume. Women were randomly assigned to receive an additional complex urodynamic evaluation. Management was determined by the surgeon, who had access to the results of the urodynamic evaluations performed. The results of the study suggested no difference in resolution of SUI for women who underwent the urodynamic evaluation compared to those who

underwent only the basic office evaluation. In the study, over 93% of the participants underwent a midurethral sling. Surgical management did not appear to be significantly impacted by the urodynamic evaluation in this population of women with uncomplicated, objectively confirmed SUI. The results of this study suggest that a simplified office evaluation is appropriate for the surgical management of uncomplicated SUI. However, it should be noted that these results are relevant only to patients with uncomplicated, objectively confirmed SUI. Of 4083 women screened for participation in this study, only 1375 (33%) met the inclusion criteria, suggesting that the results of this study may pertain to a minority of patients presenting for SUI evaluation. Moreover, given that the majority of the patients in this study underwent midurethral slings, the findings may not apply if other surgeries for SUI, such as a Burch retropubic urethropexy or a pubovaginal sling, are being considered. This is in part due to the increased morbidity of these procedures but also reflects the need to assess urethral function and the relative benefits of different therapeutic options, as discussed in this chapter. However, prior to surgical treatment of SUI, the clinician may have additional reasons for desiring a complex urodynamic evaluation, including concern for voiding dysfunction or the need for clarifying objective information if the history is unclear.

## TABLE 33.1
## Criteria for Surgical Management of Stress Urinary Incontinence Without Complex Urodynamic Evaluation

- Clear symptoms of stress urinary incontinence (or stress predominant mixed urinary incontinence)
- Postvoid residual volume < 150 mL
- Hypermobile urethra
- Positive "stress test" with objective confirmation of urine loss with cough or Valsalva
- No pelvic organ prolapse >1 cm beyond the hymen during Valsalva (stage II prolapse)
- No prior anti-incontinence surgery
- No history of radical pelvic surgery or radiation
- No neurologic disease

In neurologically intact patients without urinary retention or bladder outlet obstruction, simple cystometry may provide valuable information with fewer associated costs than multichannel urodynamics. In simple cystometry, a red rubber catheter is placed into the urethra. When performed immediately after voiding, this measures the postvoid residual. Following this, a catheter-tip syringe is attached to the catheter and the bladder retrograde filled with sterile water or saline by gravity fill. Bladder sensation is assessed: (1) the first sensation of bladder filling (defined as the feeling when the patient first becomes aware of bladder filling; this is distinct from the sensation of cold fluid) followed by (2) the first desire to void (defined as the first feeling that the patient may wish to pass urine), (3) normal desire to void (defined as the feeling that would lead the patient to pass urine at the next convenient moment), (4) strong desire to void (defined as the persistent desire to pass urine without fear of leakage), and (5) maximum cystometric capacity (defined as the bladder volume when the patient feels she can no longer delay micturition). During filling, note if the meniscus of the instilling fluid rises in the absence of an obvious Valsalva maneuver; this suggests an involuntary detrusor contraction. When the bladder is full, the catheter is removed and the patient asked to cough. Demonstrable leakage suggests SUI. If the leakage is prolonged and the entire

bladder empties, one needs to consider that the cough provoked a detrusor contraction.

# NONSURGICAL TREATMENT OF SUI

Treatment options range from conservative therapy to surgery. Conservative therapies include behavioral and lifestyle modifications including weight loss, pelvic floor muscle exercises, and use of a continence pessary or other vaginal device to improve urethral support.

Weight loss is a treatment option for SUI among obese patients but should not preclude discussion of other therapies. A systematic review found high-quality evidence that weight loss interventions such as diet and exercise moderately decreased SUI by 15%-18% at 1 to <3 years. Unfortunately, weight loss is difficult to maintain, and a large study by Phelan and colleagues with >6-year long-term follow-up found that the initial reduction in SUI following weight loss was not maintained long term. Among those who maintained decreases in BMI, a lower prevalence of urinary incontinence overall and SUI persisted long term.

Pelvic muscle rehabilitation is another effective nonsurgical therapy for SUI. Dumoulin and colleagues found that women with SUI undergoing pelvic floor muscle therapy are 8-fold more likely to be cured and 17-fold more likely to be improved or cured than controls. Pelvic floor muscle exercises may be self-initiated, but for most patients, optimal results from pelvic floor muscle therapy are achieved by working with a pelvic floor physical therapist. Successful pelvic floor muscle exercises, also known as Kegel exercises, involve both an internal tightening and lifting of the pelvic floor, with attention to both the contraction and relaxation phases of exercise. Quick, repetitive exercises strengthen the fast-twitch muscle fibers, and sustained contractions optimize function of the slow-twitch muscle fibers of the pelvic floor. Breathing exercises, attention to posture, and the ergonomics and mechanics of how the patient sits and moves all impact the pelvic floor. At 12-month follow-up following pelvic floor muscle therapy in the Ambulatory Treatments for Leakage Associated with Stress Incontinence (ATLAS) trial by

Richter and colleagues, 54% of women were satisfied with the treatment and 68% continued to perform the behavioral therapy. One rationale for a supervised program of pelvic muscle exercises is that a well-intentioned patient could mistakenly perform Valsalva maneuvers or inadequately relax between exercises, resulting in harm to the pelvic floor or high-tone pelvic floor dysfunction. The Leva pelvic health system (Renovia Inc, Boston, Massachusetts) is a motion-based digital therapeutic device, which provides real-time feedback on pelvic muscle exercises. In a randomized trial, there was a significant improvement in SUI symptoms and reduction in SUI episodes with Leva compared to a home training program (written and video instructions), with 44.1% compared to 28.8% reporting that they were “much” or “very much improved.” Weighted cones may help some patients learn how to perform the exercises correctly, but these are no more beneficial than pelvic physical therapy.

Vaginal devices may be effective therapy for SUI. The most commonly used medical device is a continence pessary. There are a variety of types from continence rings used solely for incontinence to continence dishes and rings with support that address pelvic organ prolapse as well. Most are made out of silicone and may have internal hinges to allow folding for ease of placement and removal. Fitting is done by a medical provider. In a randomized trial by Richter, Burgio and colleagues, 40% of women reported being “much better” or “very much better” following a continence pessary and 50% were satisfied with the treatment. In the short term, there was additive benefit to concurrent pelvic floor muscle therapy, but these cumulative benefits waned at a year. Unfortunately, the term “pessary” has connotations that may limit the willingness of patients and providers to try this therapeutic option, especially for young patients. Acceptance can be improved by highlighting that these are modern devices that provide additional support to the urethra, thus functioning as a brace, similar to a sports brace used to support an injured joint. Patients may choose to wear the device daily or only during high-impact activities such as during exercise. Additionally, there are options that do not require a visit to a health care professional. Uresta (Resilia Inc, New Brunswick, Canada) is a

continence pessary that comes with its own sizing kit. Impressa (Kimberly-Clark Worldwide, Inc., Irving, Texas) is a disposable intravaginal device engineered to have additional support at the lateral vaginal fornices, which is inserted like a tampon. Both Uresta and Impressa are available online.

Systemic estrogen replacement should not be recommended as treatment for SUI. Several studies have demonstrated that patients on systemic estrogen therapy have a nearly twofold higher incidence of SUI compared to patients taking placebo.

# SURGICAL TREATMENT OF SUI

As a general principle, surgery for SUI should only be performed following objective confirmation of SUI and the confirmed absence of urinary retention. In rare cases, such as an athlete that only leaks during high-impact activities that cannot be reproduced in the office, objective confirmation of SUI can be obtained with a phenazopyridine (Pyridium, Gemini Laboratories, LLC, Bridgewater, New Jersey) pad test during the provocative activity.

The most well-studied surgery for SUI is the midurethral sling, an implant composed of type I polypropylene macroporous mesh. This procedure can be performed in a retropubic or transobturator fashion, both of which yield excellent results and have become the mainstays of current surgical therapy. In the trial of midurethral slings (TOMUS), Richter and colleagues found 85%-90% patient satisfaction following retropubic and transobturator midurethral slings, and 80.8% and 77.7% objective success, respectively. Multiple retrospective case series have shown continence is maintained at 17 and 20 years. A systematic review by Schimpf also confirmed an excellent safety profile during 20 years of follow-up.

For the purposes of this chapter, the term “midurethral sling” will refer to full-length, multi-incision retropubic and transobturator mesh slings as they have been the most well-studied. Single-incision mini-slings are also placed at the midurethra, but lack an exit site through the skin and involve a shorter length of mesh. There is more heterogeneity in how these products are attached to the pelvic tissues and how they are tensioned, which appears to impact safety

and efficacy. At least one product, that is no longer on the market, had inferior efficacy to full-length midurethral slings. A randomized noninferiority trial by Dr. Abdel-Fattah and colleagues found that Ajust (C.R. Bard Inc, Covington, Georgia) and Altis (Coloplast, Minneapolis, Minnesota) adjustable anchored mini-slings were not inferior to retropubic or transobturator midurethral slings at 36 months by patient-reported success, pad count, quality of life, and safety outcomes. More women with mini-slings received further surgery, 8.7% vs 4.6% (risk difference 95% CI 4.1, [−1.1 to 9.4]) mostly for treatment of persistent SUI, pain, or mesh exposure and more had dyspareunia, 11.7% vs 4.8%.

Despite the abundant safety data on midurethral slings, patients may present with concerns about the use of vaginal mesh. It is imperative that surgeons take the time to clarify the terminology, data, and FDA statements regarding midurethral slings and how these procedures are distinct from vaginal mesh kits for pelvic organ prolapse (which are no longer on the market). In 2011, when the FDA issued a public health notification regarding transvaginal pelvic mesh used to treat pelvic organ prolapse (as well as single-incision slings), the FDA stated that “the safety and effectiveness of multi-incision slings is well established in clinical trials that followed patients for up to 1 year.” The safety and high efficacy of midurethral slings has been endorsed by several professional societies, including the American Urogynecologic Society, the Society of Urodynamics, Female Pelvic Medicine and Urogenital Reconstruction, the American College of Obstetricians and Gynecologists, and the International Urogynecological Association. (A useful patient handout is available from the American Urogynecologic Society and the Society of Urodynamics, Female Pelvic Medicine and Urogenital Reconstruction, at www.augs.org/assets/1/6/Patient_FAQs_MUS_for_posting.pdf.)

The other surgical options for treating SUI include a pubovaginal sling, Burch retropubic urethropexy, and urethral bulking agents. The Marshall-Marchetti-Krantz procedure is another alternative but has been largely abandoned due to the risk of osteitis pubis and poor long-term outcomes. There is no role in modern practice for the Kelly

plication, anterior repair, paravaginal repair, or needle suspensions for the treatment of SUI.

## Retropubic Midurethral Sling Procedures

Midurethral slings were first introduced as tension-free vaginal tape slings in 1996 by Ulmsten and colleagues. Prior to this, over 200 surgeries for SUI had been described, many of which were partially obstructive and often focused on bladder neck support with surgical correction of urethral hypermobility. The development of midurethral slings reflected an alternative understanding of the anatomy and function of the female urinary continence mechanism as described in the integral theory by Petros and Ulmsten in 1990 and the hammock hypothesis by DeLancey in 1994. A novel departure from prior procedures, midurethral slings provide a backboard of support for the urethra without any tension on the urethra or bladder neck. Clinical trials estimate that midurethral slings are associated with substantially lower rates of obstructive voiding commonly seen with previous surgical treatments.

Key aspects of the midurethral sling procedure are performed percutaneously and, therefore, blindly. As such, knowledge of anatomic landmarks is essential. The surgeon uses external and bony landmarks as reference points in order to achieve safe sling placement (**FIG. 33.3**).

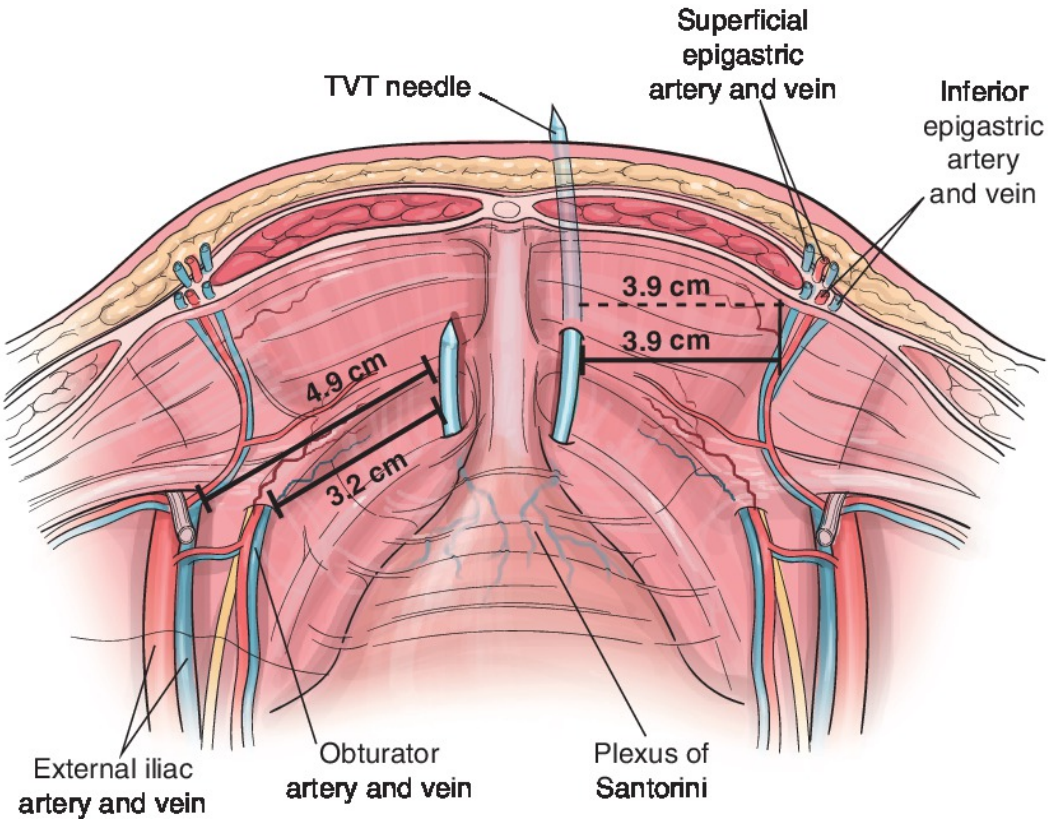


**FIGURE 33.3** Retropubic trocars in the space of Retzius. The trocars enter the retropubic space ~2-3 cm from the midline. In this position, they are medial to the inferior epigastric, obturator, and accessory obturator vessels. The pubic branches of the obturator vessels are seen to course medially along the surface of the pubis.

Commercially available midurethral retropubic slings consist of a narrow strip of polypropylene mesh and rigid trocars for insertion.

A retropubic midurethral sling is performed in lithotomy position (**FIG. 5.2**), with slight Trendelenburg. The bladder is drained with a catheter, as this minimizes the risk of bladder injury. The location of the suprapubic incisions is marked 2 cm lateral to the midline. The

suprapubic level for the incision is identified by rolling a finger just over the top of the pubic bone. Keeping these incisions close to the pubic bone further ensures that the trocar trajectory remains in the retropubic space (avoiding the peritoneal cavity). More lateral placement will increase the risk of neurovascular injury. If performing under local anesthesia, dilute anesthetic such as bupivacaine with epinephrine is injected in the retropubic space using a spinal needle, thus anesthetizing along the path of trocar placement.

A Sims retractor is placed vaginally. The midurethra is identified by palpating the Foley balloon at the bladder neck. Allis clamps are placed 1 cm proximal to the urethral meatus and another at the bladder neck (if performing under local anesthesia, anesthetic is placed prior to placement of the Allis clamps). Anesthetic may be injected suburethrally and paraurethrally. A 1.5-cm incision is made at the midurethra (**FIG. 33.4A**). The depth of the incision determines the future location of the sling. It must be deep enough to prevent future vaginal mesh exposure, yet remain a safe distance from the urethral lumen. Placement at the midurethra is critical, as noted in an ultrasound study by Hegde and colleagues. They found that sling failure is associated with placement at locations other than the midurethra. (If concomitant anterior vaginal surgeries, such as an anterior repair, are being performed, the surgeon should consider placing the sling through a separate 1.5-cm midurethral incision in order to minimize the risk of sling migration toward the bladder neck.)

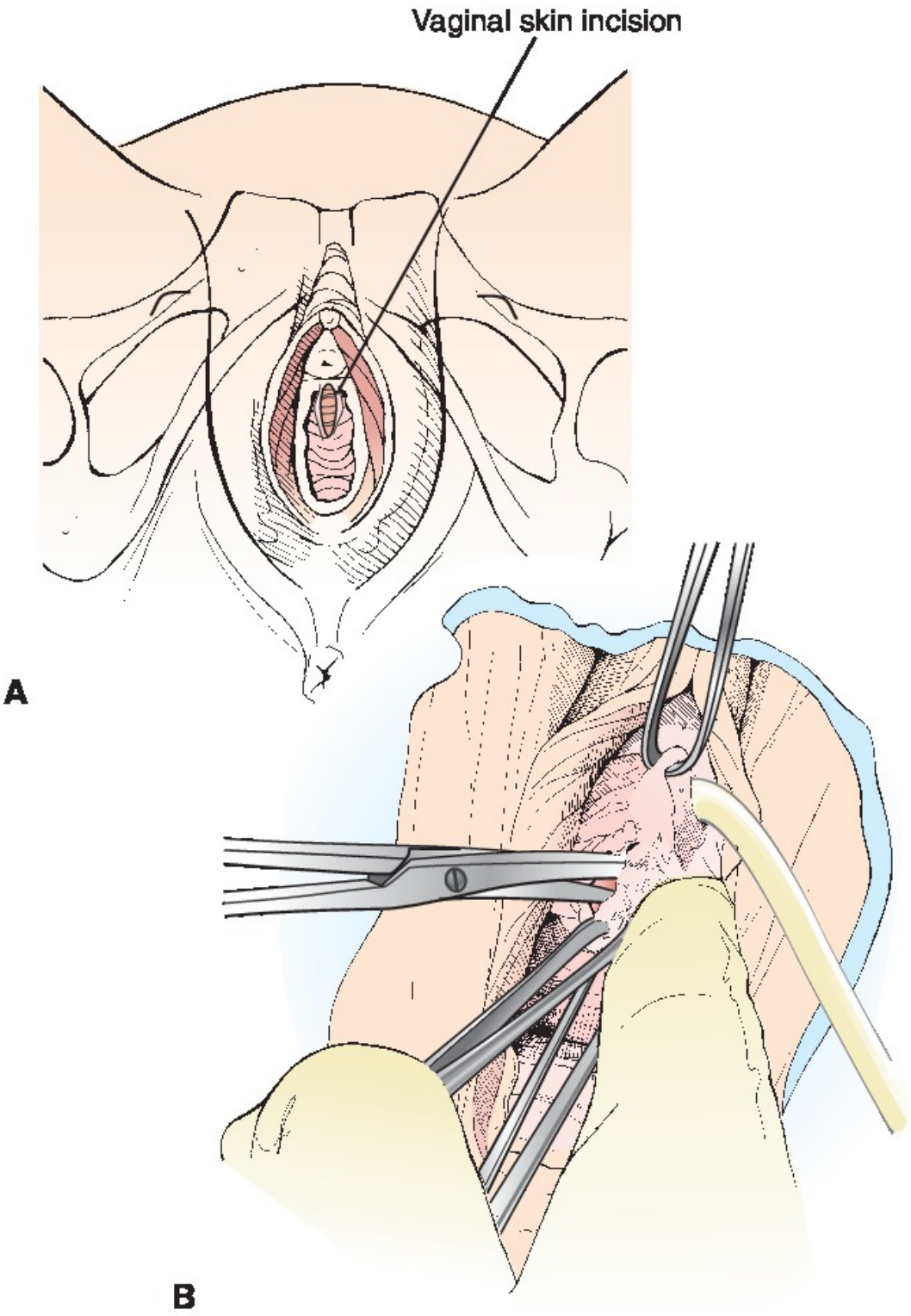


**FIGURE 33.4** **A.** The vaginal incision for a midurethral sling procedure is ~1.5 cm in

length and is located at the midurethra, typically 1-1.5 cm from the urethral meatus. **B.** For a retropubic midurethral sling, fine scissors are used to dissect a subepithelial tunnel, typically 2 cm in length. The angle of the tunnel is typically at 45°, aimed toward the junction of the inferior pubic ramus and the pubis.

Additional Allis clamps may be placed on either edge of the incision to facilitate countertraction. Using Metzenbaum scissors, bilateral paraurethral tunnels are created, ~2 cm in length (**FIG. 33.4B**). Countertraction during this dissection is maintained by gentle tension on the Allis clamp, while maintaining the index finger under the pubic bone and against the vaginal tissue. The remainder of the dissection is performed with the trocars, as their shape allows the surgeon to hug the pubic bone and remain retroperitoneal, thus minimizing unnecessary dissection into the paraurethral vascular plexus or extension into the plexus of Santorini.

A rigid urethral catheter is traditionally passed through the urethral catheter and deflected to deviate the bladder neck away from the side of trocar placement and minimize the risk of bladder injury. This deviates the bladder neck about 1.4 cm. Given that trocar injury is exceedingly rare at the bladder neck, some surgeons omit this step. The Sims speculum is removed and the bed lowered in order to optimize the trajectory, leverage, and ergonomics needed for trocar passage.

Safe retropubic trocar passage requires the surgeon to know the exact location of the tip of the trocar at all times, even though passage is done blindly. This requires awareness of the angle and trajectory of the trocar and continual contact of the trocar tip against the back of the pubic bone throughout needle passage. It can be conceptualized in two phases.

In the first phase of sling passage, the goal is to perforate the retropubic space at a safe (avascular) location. This is achieved by keeping the trocar aimed toward the pubic tubercle, ~2 cm lateral from the midline and in line with the ipsilateral shoulder. Entering the retropubic space at the junction of the pubis and inferior pubic ramus will maintain the trocar in a relatively avascular portion of the retropubic space. Cadaveric studies reveal that with appropriate placement, the sling passes medial to the arcus tendineus fascia pelvis in the majority of cases, but 25% of the time passes lateral to the arcus and perforates the pubococcygeus muscle (**FIG. 33.5**). In cadaveric studies, the mean distance from the trocar to nearby vessels was 1.5-4.3 cm to the obturator vessels, 1.9-6.6 cm to the inferior epigastric vessels, and 2.9-6.2 cm to the external iliac vessels (**FIG. 33.3**). If the trocar is directed too laterally, the external iliac vein may be punctured. Prior to passing the trocar, confirm that the trocar tip is making contact with the pubic bone; it is not safe to pass the trocar without this haptic feedback. With one hand on the handle of the trocar, the surgeon's other hand braces the index finger under the pubic bone, with thumb and forefinger supporting the curve of the trocar to facilitate safe, controlled passage through the periurethral tissue (**FIG. 33.6**).

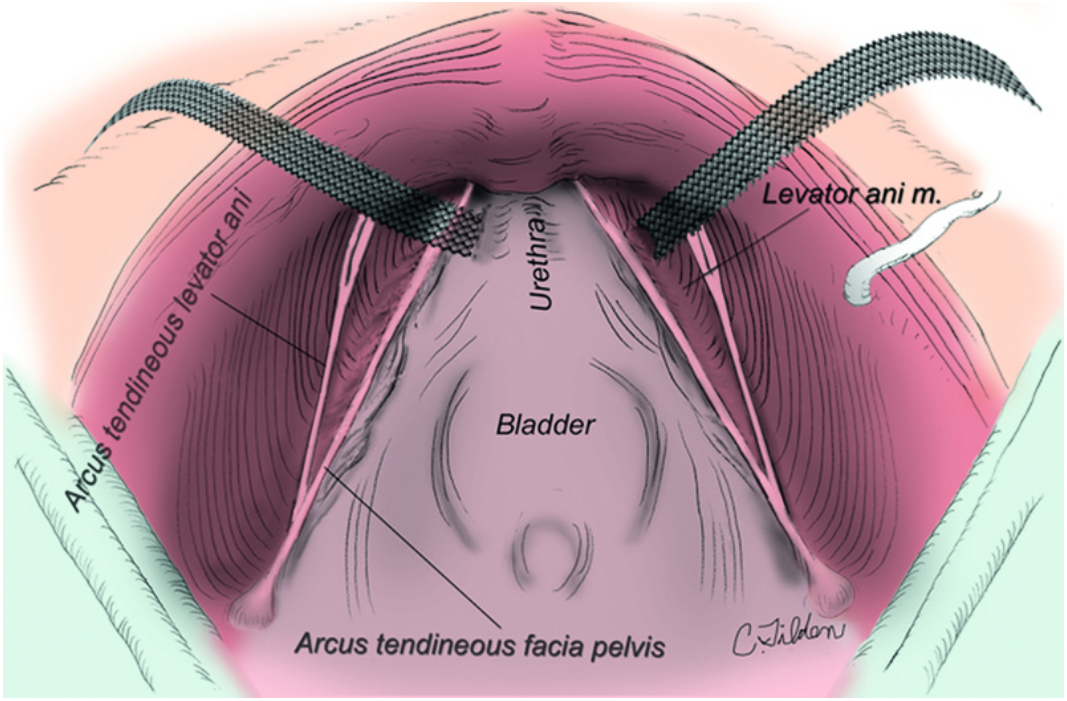


**FIGURE 33.5** Retropubic space illustration showing location of a retropubic sling. The sling on the right passes lateral to the arcus tendineus fascia pelvis (ATFP), perforating the levator ani muscle complex. The sling on the left is in the more typical location, medial to the ATFP. (Reprinted from Rahn DD, Marinis SI, Schaffer JI, et al. Anatomical path of the TVT: reassessing current teachings. *Am J Obstet Gynecol*. 2006;195(6):1809-1813. Copyright © 2006 Elsevier. With permission.)

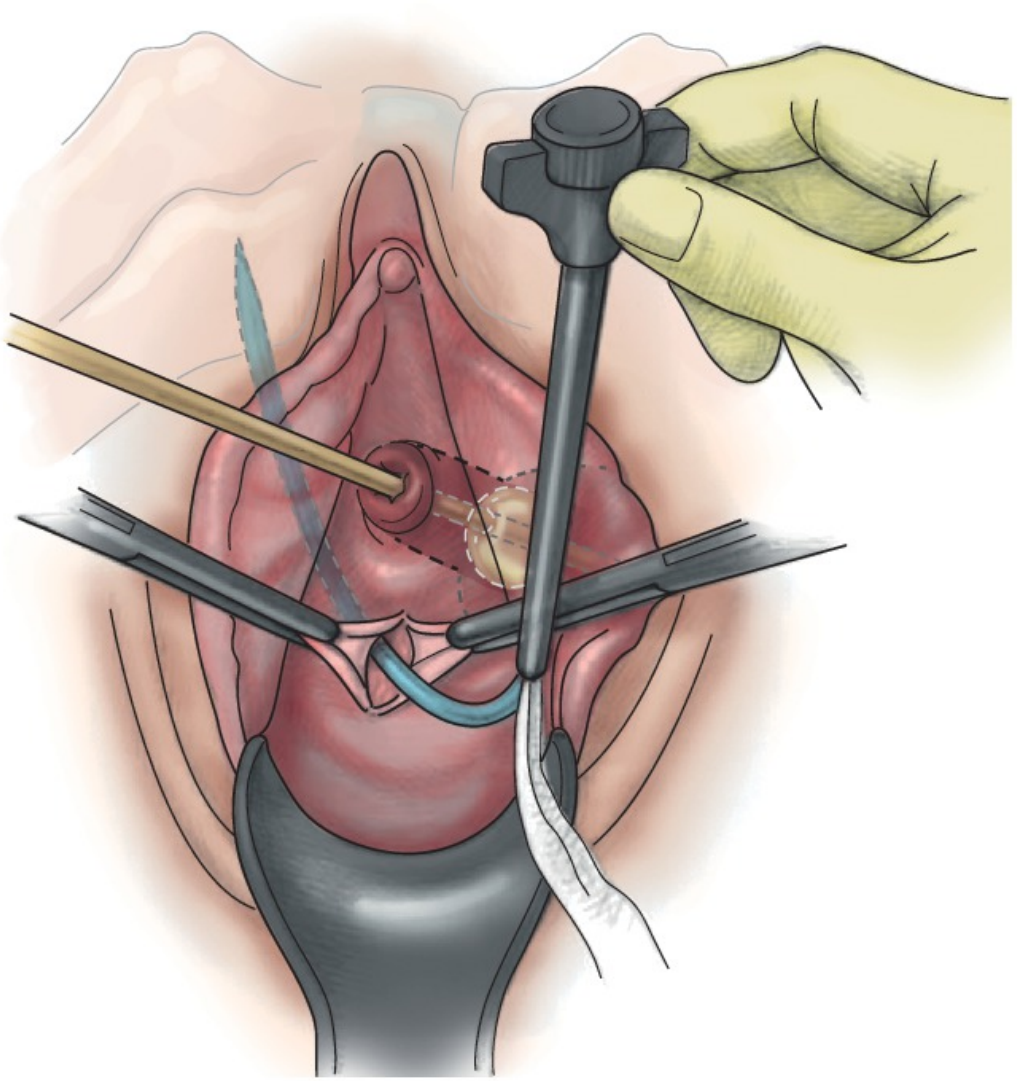

**FIGURE 33.6** With the rigid catheter guide deviating the bladder to the left, the curved trocar is inserted in the retropubic position. The trocar perforates the retropubic space at the junction of the inferior pubic ramus and the pubis, immediately along the surface of the bone.

In the second phase of trocar placement, after the tip of the trocar has entered the retropubic space as described above, the goal is to pass the trocar through the retropubic space along the back of the pubis, exiting the skin without vascular or organ injury (**FIG. 33.7**). To accomplish this, contact is maintained with the bone throughout retropubic passage by hugging the tip of the trocar to the back of the pubic bone. This is accomplished by dropping the hand holding the trocar (and necessitates that the bed level is not too high). If the Sims speculum is still in place, it will prevent optimal dropping of the surgeon's hand as the trocar will hit the speculum. The trocar can aim toward the suprapubic incision on the ipsilateral side. After passage of the trocar, digitally palpate the vaginal fornix to confirm there is no vaginal perforation.

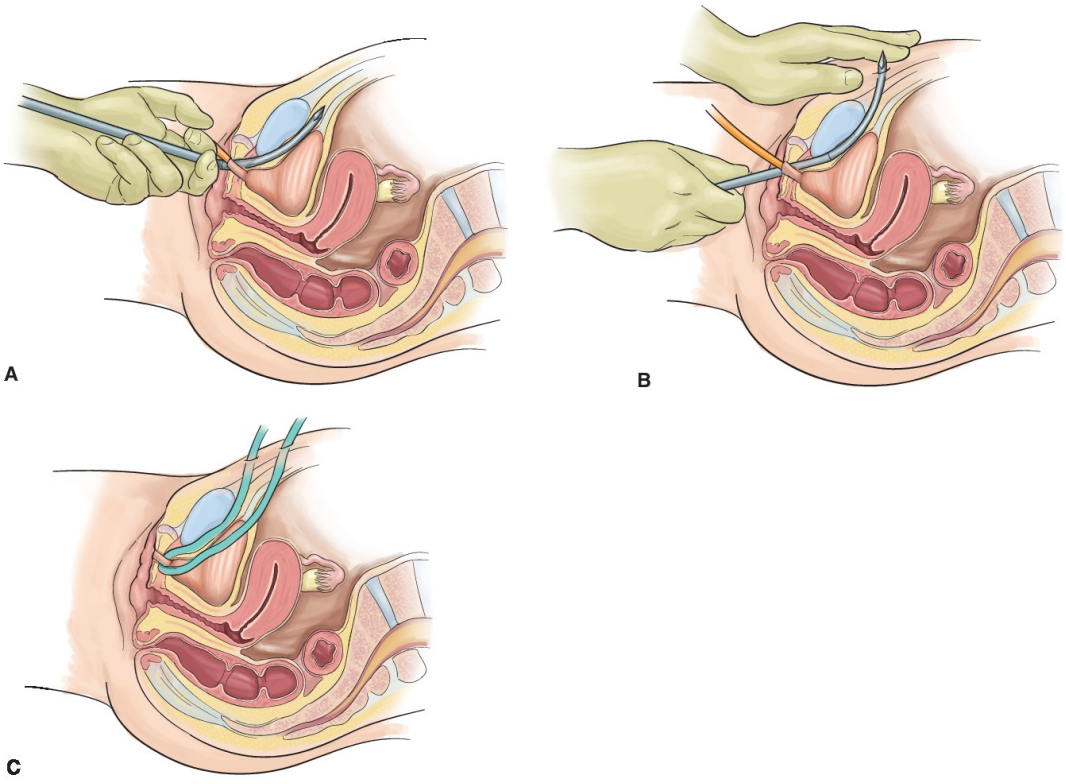


**FIGURE 33.7** Insertion of vaginal tension-free tape. **A.** Vaginal guidance of needle under inferior pubic ramus along back of symphysis.

**B.** Pressure over the skin of the abdomen to allow the needle to penetrate the abdominal skin. **C.** Both needles passed through retropubic space and resting on the abdomen. (From Klutke J, Klutke C. The promise of tension-free vaginal tape for SUI. *Contemp Urol Arch*. 2000;October:Figures 4, 6, and 7. Reprinted with permission from John Klutke, MD.)

Alternatively, retropubic slings can be performed with a top-down approach, a technique often marketed toward urologists as it mimics the trajectory used with Pereya and Stamey needles. Of note, the top-down approach has lower efficacy and is associated with more voiding dysfunction, bladder perorations, and vaginal exposures.

Following trocar passage, cystoscopy is performed with a 70° scope (**FIG. 33.8**). The bladder should be completely filled (300-500 mL) to ensure there are no bladder folds, which could mask a trocar perforation. If a bladder injury occurs, it typically happens on the anterior and nondependent aspect of the bladder and the trocars can be removed and replaced.

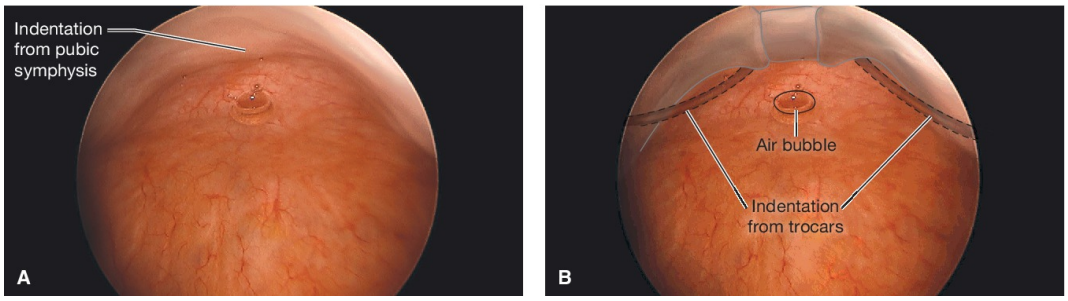


**FIGURE 33.8** Cystoscopy is performed with the retropubic trocar in place.

During cystoscopy, in addition to ensuring there is no trocar perforation, the surgeon can visually confirm retropubic trocar passage by identifying the indentations along the bladder lumen from the trocars and their relationship with the indentation from the pubic symphysis and the air bubble at the dome of the bladder. With correct placement, visualization during cystoscopy will reveal the trocars passing cephalad to the symphysis, with the air bubble cephalad to the trocars. If the relationship between these landmarks is altered, such as the air bubble being caudal to the location of the trocars, one needs to be concerned that the trocar exited the retropubic space and could be intraperitoneal.

There are multiple techniques to ensure correct tension is placed on the sling. Specifically, the sling should be adjacent to the urethra but not under tension. Options include tensioning over a Kelly clamp, Mayo scissors, or a Hegar dilator. Another approach is to grasp a small knuckle of tape with a Babcock clamp during tensioning. In the randomized MUST trial, the Babcock technique had 12.9% fewer abnormal bladder outcomes compared to tensioning over a scissor. They used a composite outcome that assessed for persistent SUI, overactive bladder symptoms, need for SUI retreatment, or retention requiring catheterization ≥6 weeks or sling revision. Vaginal mesh exposure was more common with the Babcock technique (5.3% vs 0.7%). Regardless of the modality used, one should adhere to the principles of avoiding redundant mesh in the paraurethral tunnels and to ensuring that the sling is loose and not under tension. Typically, the rate of sling release secondary to obstruction is higher than the rate of sling failure due to placement being too loose, thus emphasizing the importance of tension-free placement. With the spacer or Babcock clamp in place, the clear plastic sheaths are removed. This sets the sling in place, without any sutures needed to secure placement. Excess suprapubic mesh is cut just under the skin and the incisions are closed with suture or surgical skin adhesive. The vaginal incision is closed with delayed absorbable suture, with no sutures attached to the sling (**BOX 33.1**).

## BOX 33.1 STEPS IN THE PROCEDURE

## Retropubic Midurethral Sling

- The patient is positioned in Allen stirrups.
- A Foley catheter is placed and the bladder is drained.
- Suprapubic marks are made 2 cm lateral to the midline, directly above the pubic bone.
- The retropubic space may be injected with dilute local anesthetic for hydrodissection.
- An anterior vaginal wall incision (1.5 cm) is made over the midurethra.
- Using Metzenbaum scissors, a paraurethral tunnel is created under the vaginal wall, oriented at 45° (toward the inferior pubic ramus), until the scissor tips make contact with the inferior surface of the pubic bone.
- The bladder is deviated away with a catheter guide and the bed lowered.
- The insertion trocar is placed through the vaginal incision and paraurethral tunnel. The tip of the trocar is guided to perforate into the retropubic space while maintaining contact with the bone.
- The trocar is guided through the retropubic space while maintaining contact of the tip of the trocar with the back of the pubic bone. This is facilitated by dropping the hand holding the trocar handle. Aim toward the ipsilateral suprapubic skin incision until the trocar passes through this point on the abdominal wall.
- Cystoscopy is performed with the trocar in place.
- The trocar is pulled through the abdominal wall.
- After the same procedure is repeated on the contralateral side, the sling is tensioned with a spacer (such as a 9 Hegar dilator) between the sling and the urethra and the plastic sheath removed.

- The sling arms are trimmed at the skin, and the incisions are closed.
- A voiding trial is performed before discharge.

## *Postoperative Voiding Trial*

Temporary urinary retention is common following a sling procedure and can be affected by use of spinal anesthesia and concurrent pelvic floor surgery, such as an anterior repair. All patients should have a voiding trial after surgery. If the patient has significant urinary retention, catheterization will be necessary (either via intermittent self-catheterization or indwelling Foley) until voiding function returns. One approach to the trial of void is to retrograde fill the bladder with 300-mL sterile water, remove the catheter, and record the voided and postvoid residual volumes. Voiding two-thirds or more of the total volume (≥200 mL) with a residual of ≤100 mL suggests adequate voiding function.

# Transobturator Midurethral Sling

The transobturator approach was introduced in 2001. Benefits of the transobturator approach (compared to the retropubic approach), as noted in a systematic review by Schimpf and colleagues, are lower rates of intraoperative bleeding, bladder perforation, urinary retention, and overactive bladder symptoms. Disadvantages include increased incidence of vaginal mesh exposures, return to the operating room for sling exposures, nerve injury, ureteral injury, and groin pain. Randomized trials, including the TOMUS trial, have found no difference in efficacy between retropubic and transobturator approaches, and both are excellent modalities for the surgical treatment of SUI. In a randomized trial by Schierlitz and colleagues comparing retropubic and transobturator midurethral slings in population of 164 women with intrinsic sphincter deficiency, 21% had persistent urodynamic SUI following a retropubic compared to 45% following transobturator midurethral slings at 6 months. At 3 years, 1.4% of women with a retropubic sling underwent repeat surgery, compared to 20% of women with transobturator midurethral slings.

Multiple studies have compared inside-out and outside-in transobturator approaches, with similar success rates and adverse outcomes with both approaches.

Midurethral placement is just as critical for a successful outcome with the transobturator as compared to the retropubic approach. The patient is positioned in a dorsal lithotomy position with the legs high enough that the adductor longus tendon is away from the groin incisions (**FIG. 33.9**). It is essential that the surgeon understands the anatomy of the obturator foramen, which is bounded medially by the inferior pubic ramus. The obturator neurovascular bundle passes through the obturator canal at the superolateral aspect of the obturator foramen. Regardless of whether the surgeon elects the outside-in or inside-out approach, transobturator sling passage requires helical trocars. These helical trocars hug the inferior pubic ramus and pass along the medial aspect of the obturator foramen. The angle and trajectory of the trocar is also essential to ensure that the sling forms a “U” shape under the urethra and does not hang low in the vagina like the crossbar of an “H.” Groin incisions should be near the level of the clitoris and superior to the level of the urethral meatus. A common mistake is to rotate the trocar along the natural curve of the helical needle, instead of actively guiding the trocar tip to stay along the inferior pubic ramus, particularly with an inside-out approach.

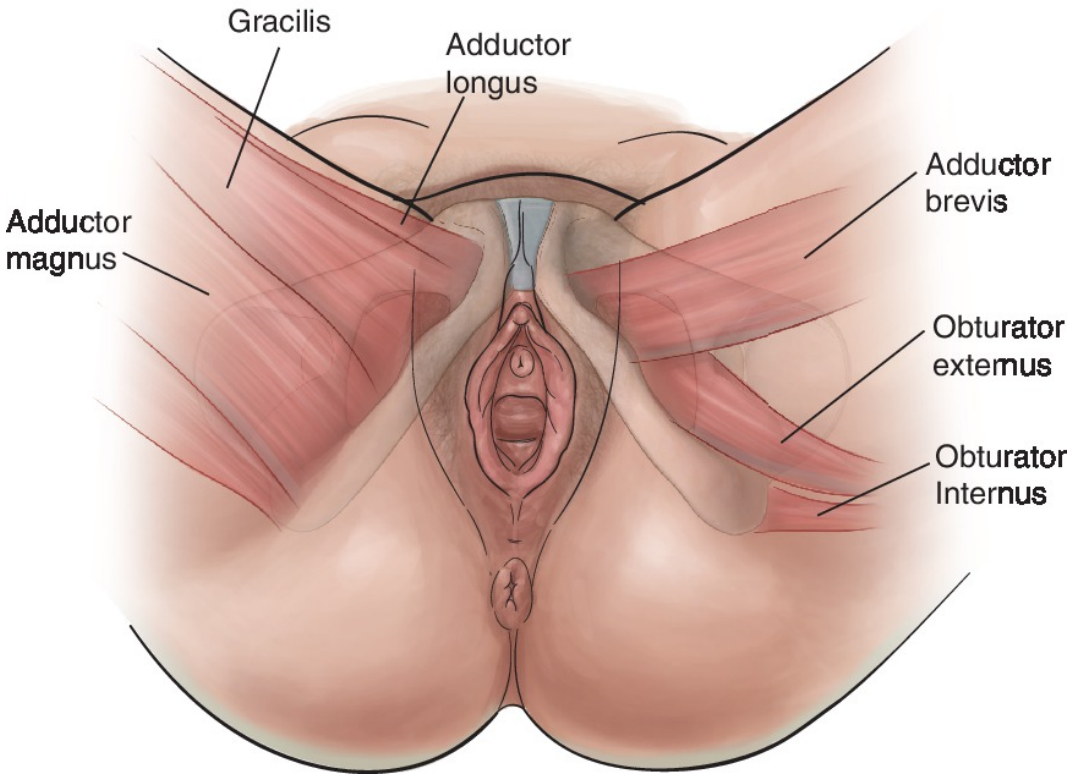


**FIGURE 33.9** Along the path of the transobturator sling, potentially vulnerable structures include the muscles of the medial thigh, including the gracilis, adductor brevis, adductor longus, and adductor magnus.

Since the retropubic space is avoided with a transobturator approach, no urethral catheter guide is needed to deviate the bladder neck away from the trocar. Similarly, leverage and bed height does not need to be adjusted during trocar passage, as the retropubic space is not traversed.

Similar to a retropubic sling, a catheter is placed before sling placement to ensure that the bladder is empty and the midurethral incision is performed in the same manner. Metzenbaum scissors are used to create paraurethral tunnels to the pubic bone, similar to a retropubic sling.

For an outside-in approach, the midurethral incision is extended and additional dissection is performed with Metzenbaum scissors in order to allow the surgeon's finger to pass along the paraurethral tunnel and laterally to reach the superior aspect of the inferior pubic ramus (**FIG. 33.10**). Despite this additional dissection, the same principle applies that the sling needs to be deployed at the midurethra. Next, a groin incision is made at the level of the clitoris, below the adductor longus tendon, and immediately lateral to the inferior pubic ramus. The helical trocar tip enters the groin incision and makes contact with the inferior pubic ramus and then hugs the back of the bone until it reaches the surgeon's finger in the paraurethral tunnel (**FIGS. 33.10** and **33.11**). The trocar passes through the skin, gracilis muscle, adductor brevis muscle, external obturator muscle, obturator membrane, and obturator internus muscle and exits through the periurethral endopelvic fascia (see **FIG. 33.9**). Digitally, confirm that there is no vaginal perforation. The trocar is brought through the midurethral incision and the mesh sling attached, followed by the reverse movement of the trocar to bring the mesh back out of the groin. This is done bilaterally (see **FIG. 33.11**).

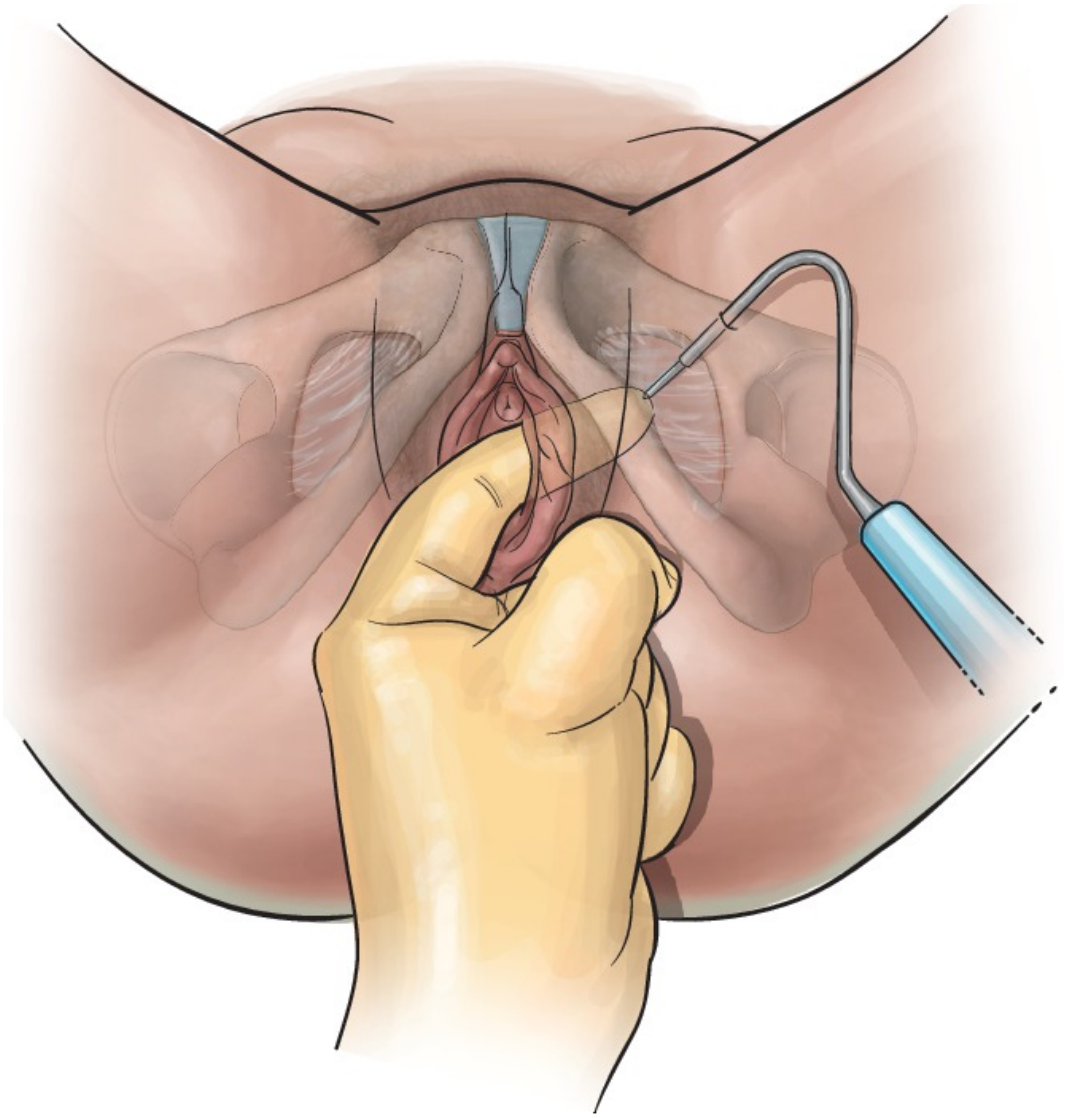

**FIGURE 33.10** Outside-in transobturator sling. The passage of the helical needle is shown, beginning at a 5-mm skin incision created ~1 cm lateral to the groin fold and at the level of the clitoris. The surgeon's finger, inserted via the vaginal incision to the ischiopubic ramus, guides the trocar into the vaginal incision.

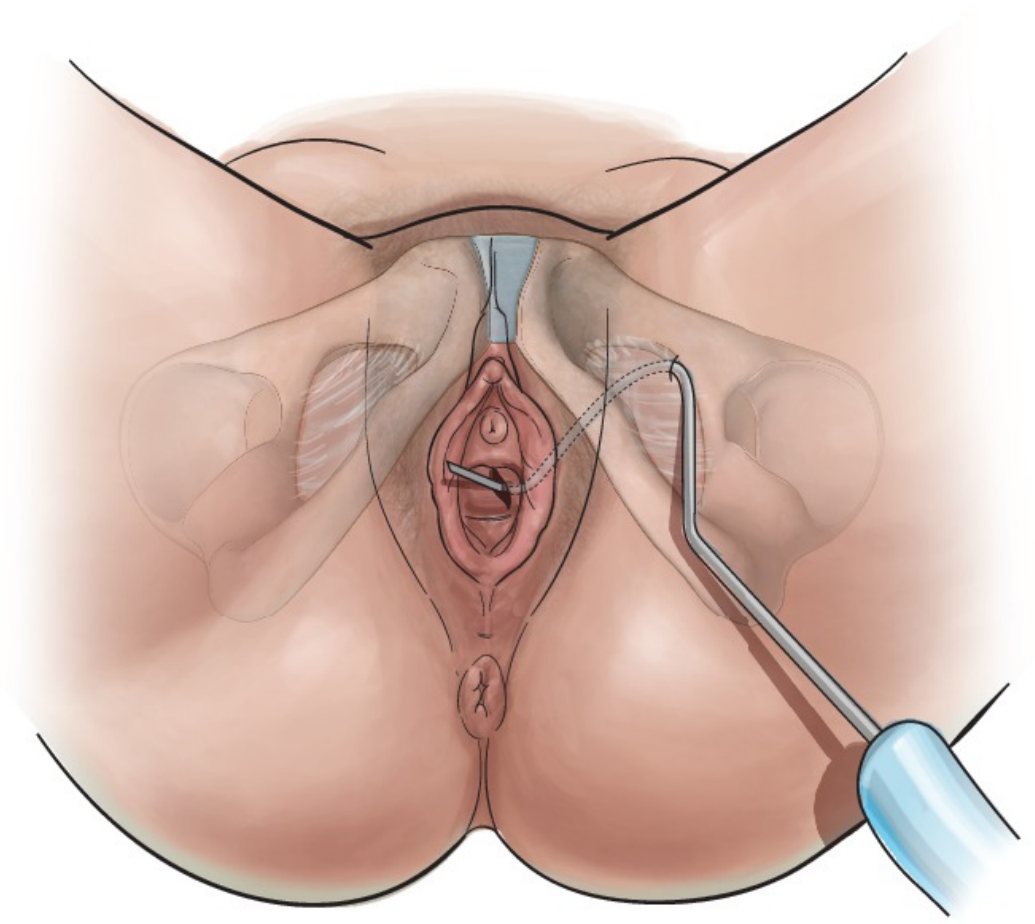

**FIGURE 33.11** The trocar for the outside-in transobturator sling is guided into the vaginal incision. The end of the sling will be attached to the trocar and then withdrawn to the skin incision.

If an inside-out approach is used, the suburethral incision can be smaller as the surgeon does not need to place a finger in the incision. The tunnel on each side should extend to the inferior pubic ramus. A winged guide is passed in the paraurethral tunnel at a 45° angle until it makes contact with the inferior pubic ramus. Some surgeons advance the winged guide through the obturator membrane, while others perform that portion of the dissection with the helical trocar. In either approach, the winged guide is used to

guide the initial placement of the trocar. After the winged guide is removed, the trocar is passed behind the inferior pubic ramus, exiting at the groin incision on the medial aspect of the obturator foramen. The trocar traverses the periurethral endopelvic fascia, the obturator internus muscle, obturator membrane, obturator externus muscle, adductor brevis muscle, and gracilis muscle and exits the skin. The adductor longus tendon is avoided (see **FIG. 33.9**). When passing the helical trocar, it is imperative that the surgeon maintain the tip of the trocar along the back of the inferior pubic ramus. In order to maintain this contact, the surgeon will be pulling the tip of the trocar against the bone. If this is not done, and the surgeon allows the trocar to pass along the natural trajectory of its helical shape, there is a risk of injury to the obturator neurovascular bundle. Optimal passage of the helical needle involves having the handle start at a 45° angle but ending upright at a 90° angle with the floor when the trocar exits the groin. The curved motion of this maneuver helps maintain the tip of the trocar against the inferior pubic ramus. The trocar exits through the previously marked groin incisions (**FIG. 33.12**).

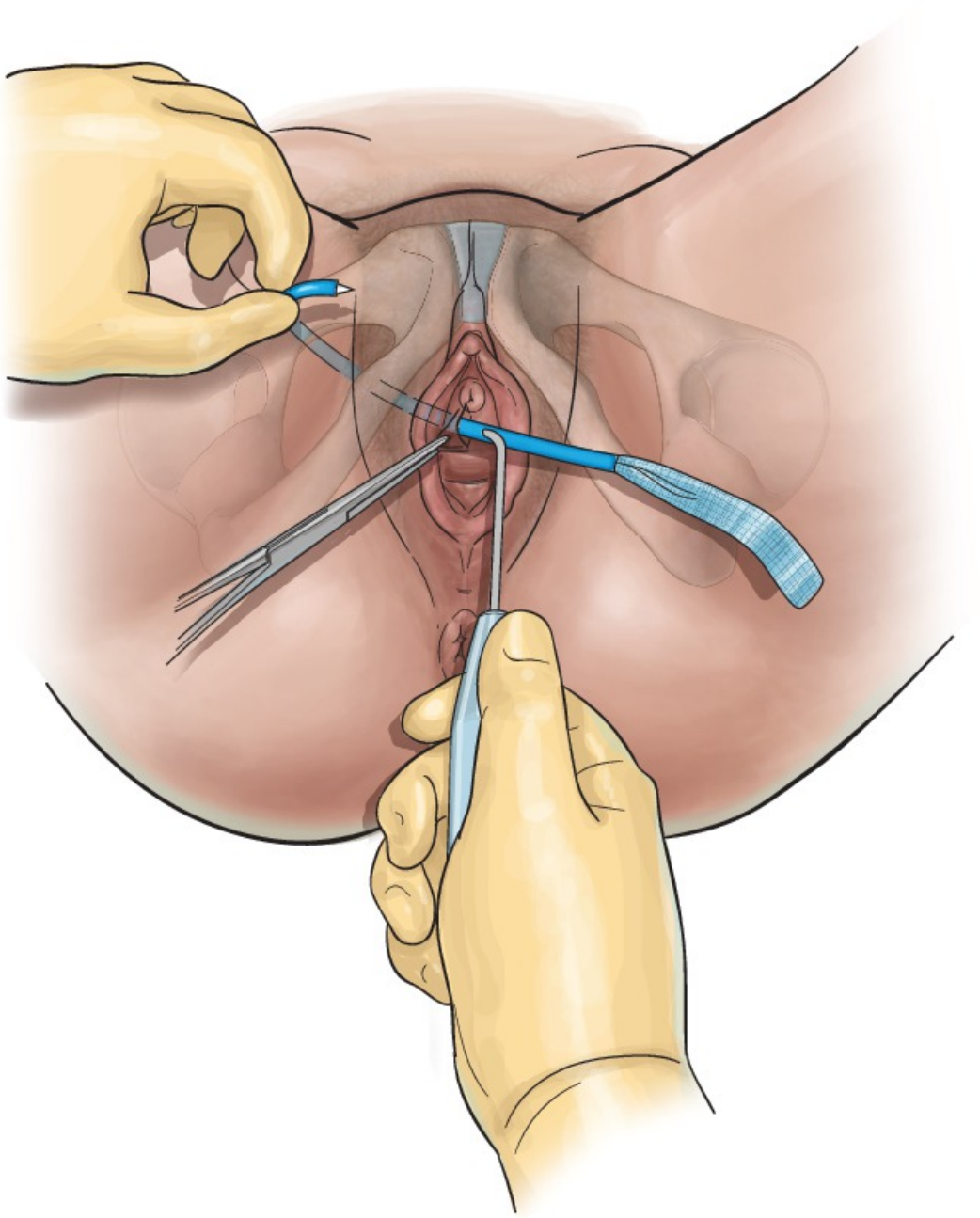

**FIGURE 33.12** Inside-out transobturator sling. The passage of the helical needle is shown, exiting the skin ~1 cm lateral to the groin fold about 2 cm superior to the urethral meatus and parallel to the clitoris.

Following passage of the trocars, similar steps to a retropubic sling are performed. Vaginal palpation is performed to confirm no trocar perforation. Cystoscopy is performed with a 70° scope. Bladder injury can and has occurred with a transobturator sling; it is imperative that cystoscopy be done at the time of the procedure as well as visualization of bilateral ureteral efflux. Following cystoscopy, the sling is tensioned in a similar manner as a retropubic sling, the plastic sheaths removed, and the suburethral incision closed with a delayed absorbable suture. Excess mesh is excised at the groin, and these incisions are closed with a delayed absorbable suture or skin glue (**BOX 33.2**).

## BOX 33.2 STEPS IN THE PROCEDURE

### Transobturator Midurethral Sling (Inside Out)

- The patient is positioned in Allen stirrups.
- A Foley catheter is placed and the bladder is drained.
- An anterior vaginal wall incision (1.5 cm) is made over the midurethra.
- Using Metzenbaum scissors, a paraurethral tunnel is created under the vaginal wall until the scissor tips make contact with the superior aspect of the inferior pubic ramus.
- The winged guide is inserted into the incision at a 45° angle.
- The helical trocar is placed through the vaginal incision, following the winged guide until the obturator membrane is pierced. The winged guide is removed.
- The handle is rotated and moved inferiorly to a vertical position while maintaining contact of the trocar tip with the inferior pubic ramus. The trocar exits on the medial aspect of the obturator foramen at the level of the clitoris.
- The same procedure is repeated on the contralateral side.

- The sling is tensioned with a spacer (such as a 9 Hegar dilator) between the sling and the urethra.
- Cystoscopy is performed.
- A voiding trial is performed before discharge.

# Complications From Midurethral Slings

## *At the Time of Surgery*

### Urethral Injury

If the midurethral incision is too deep and the urethral lumen is entered, the procedure should be aborted and no mesh placed. Urethral injury needs to be ruled out if there is bleeding from the urethral lumen when performing cystoscopy. Ensure that no urethral diverticulum is present, as that could contribute to intraluminal dissection. After repair, the urethral defect should be treated with a watertight, layered, tension-free closure. We recommend placement of an indwelling Foley for 2 weeks.

### Vaginal Trocar Perforation

If a vaginal trocar perforation is diagnosed at the time of passage, there are two options. One is to repass the trocar deeper to the vaginal wall, deploy the sling, and close the vaginal defect. If unable to repass the trocar along a deeper tract or if the defect is diagnosed after the sling has been deployed, consider removing the mesh and aborting the procedure. While the vaginal wall closure may appear satisfying in the operating room, the risk of future exposure through the vaginal epithelium is increased. If a vaginal exposure develops, the risk of subsequent sling revision may negate the benefits of sling placement. As such, it may be prudent not to deploy mesh after breach of the vaginal wall, and in this case, the surgeon may elect to reschedule the planned surgery at a future date.

## Cystotomy

Bladder perforation is more common after a retropubic midurethral sling compared to a transobturator sling, 4.5% vs 0.6%, respectively, in a Cochrane analysis. Studies by LaSala and Zyczynski found no long-term sequelae if cystotomy is identified and addressed intraoperatively. When a bladder perforation occurs, the surgeon should pause to reassess the anatomy and ensure that the perforation is limited to the bladder. During a retropubic sling, it is likely that contact of the trocar tip was not maintained along the back of the pubic bone throughout its pass. Certain comorbidities may increase the likelihood of perforation, such as increased BMI or scarring secondary to prior retropubic surgery. The trocar is removed and replaced, followed by repeat cystoscopy and Foley drainage. The duration of bladder drainage in this setting is controversial. Some individuals report good outcomes without long-term drainage, but these are isolated case reports, and this management has not been well studied. Overall, the risk of an adverse event such as urinoma, fistula, or subsequent mesh exposure in the bladder likely outweighs the short-term inconvenience of Foley catheter drainage.

If a cystotomy during a retropubic sling occurs at a location other than the anterior and cephalad aspect of the bladder, often colloquially referred to as the “bladder dome,” the trajectory of the trocar needs to be further evaluated. If injury is at the trigone, the bladder defect should be surgically closed, irrespective of retropubic, transobturator, or single-incision passage.

## Vascular Injury

With a retropubic sling, the main concern is that the trocar may deviate laterally to injure the external iliac vessels (see **FIG. 33.3**). In such cases, bleeding can be catastrophic. Fortunately, this complication can be avoided by following the surgical principles outlined in this chapter. If significant intraoperative bleeding is encountered during the retropubic sling procedure, the bleeding is more likely from the plexus of Santorini. Bleeding from this plexus may result in formation of a hematoma. Compression on the retropubic space can be performed by leaving the bladder full and

clamping the Foley for an hour in the recovery room, with vaginal packing in place. After 1 hour, the Foley can be unclamped and the packing removed. The risk of such bleeding can be minimized by not dissecting past the pubic bone during the initial paraurethral dissection and by insuring that the trocar hugs the pubis as it is passed through the retropubic space. Approximately 1% of patients will develop a retropubic hematoma, but the vast majority of these are asymptomatic and self-limited.

With a transobturator approach, the main concern is injury of the obturator vessels if trocar placement is too lateral when traversing the obturator foramen. This is avoided by having the tip of the helical trocar hug the inferior pubic ramus during transobturator passage.

Bleeding during the paraurethral dissection is a nuisance, but unless there is excessive dissection into the vesicovaginal plexus and the plexus of Santorini, such bleeding is rarely medically concerning. If the bleeding is significant, consider placement of Gelfoam in the dissected tunnels or pressure. Bleeding can be minimized and avoided by limiting the dissection with the Metzenbaum scissors and stopping when contact is made with the pubic bone. The remaining dissection is performed with the trocar, and its shape facilitates dissection along the back of the pubic bone, thus avoiding the vascular plexus deep to the bone.

# *Complications With a Delayed Manifestation*

## Urinary Retention

Urinary retention lasting beyond a few days may result from urinary obstruction (eg, from a sling that is too tight) or may be due to an underlying weak detrusor muscle. The vast majority of *de novo* urinary retention after a midurethral sling procedure will be due to bladder outlet obstruction secondary to the sling. Surgical revision with transection of the sling in the midline will release this obstruction, with 61% of women maintaining continence after transection and another 26% still having improved continence from baseline. There are scant data to guide optimal timing of sling

revision. One recommended approach is to recommend sling transection (no removal of mesh) if urinary retention persists for more than 3 weeks. A longer period of expectant management (with catheterization) should be considered for patients with a known weak detrusor muscle or who underwent concurrent surgical correction of stage IV pelvic organ prolapse, as these patients may have a delay of up to several weeks before normal voiding spontaneously returns. A 2022 systematic review found higher rates of recurrent SUI following complete vs partial excision of the sling.

## Vaginal Mesh Exposure

Vaginal mesh exposures may be more likely to occur in the setting of vaginal wall injury at the time of sling placement, vaginal wound breakdown at the midurethral incision site, incorporation of the sling into the closure, or superficial placement of the sling along the vaginal wall. The latter can occur if the initial suburethral incision is shallow and the subsequent paraurethral dissection is too close to the vaginal epithelium. The rate of this complication is low, occurring in 2.1% of retropubic and 2.4% of transobturator approaches as noted by a 2017 Cochrane review.

Treatment options include topical vaginal estrogen, trimming the mesh in the office, surgical management, and counseling with watchful waiting. Topical vaginal estrogen is most likely to be successful when the exposure is small. Some small exposures may be asymptomatic. Watchful waiting is appropriate following full disclosure of the exposure to the patient and in the absence of infection, dyspareunia, or bothersome bleeding. There are scant data about the long-term consequences of watchful waiting in the asymptomatic patient.

Surgical mesh removal may be necessary to treat a vaginal exposure; however, if a significant portion of the sling is excised, incontinence may recur. In these situations, consider consultation with a specialist (as multiple surgeries lead to more complex problems and increase the risk of developing a fixed, immobile urethra with refractory SUI). There are also case reports of successful management using an autologous graft of vaginal

epithelium, but this should only be performed by an experienced surgeon or specialist.

## Bowel Injury

This can occur if the trocar exits the retroperitoneal space and enters the peritoneal cavity. The risk of this complication is minimized by keeping the trocar immediately adjacent to the pubic bone during passage. If peritoneal entry by the trocar is suspected, immediate abdominal evaluation is needed. Early signs and symptoms include a fever, significant pain, or detection of intraperitoneal air on imaging, although delayed presentation with sepsis is possible and deaths have been reported.

## Surgical Site Pain

Persistent postoperative pain is an uncommon complication after both retropubic and transobturator slings. With a transobturator sling, the patient may have groin pain related to the mesh traversing the obturator, gracilis, adductor brevis, and adductor magnus muscles. Dyspareunia and vaginal pain can occur when the mesh lies low in the vagina, making more of an “H” than a “U” shape.

As noted in a Cochrane review, retropubic midurethral slings are associated with less groin pain, 1.3% vs 6.4%, but more suprapubic pain, 2.9% vs 0.8%, compared to transobturator slings. In a systematic review and meta-analysis by Schimpf and colleagues, leg pain was less likely to occur after retropubic compared to transobturator midurethral slings (0.62% vs 16%). Nerve injury is more common following transobturator vs retropubic slings (0.61%, compared to 0.06%); irritation of the obturator nerve presents with pain along the medial thigh and difficulty with leg adduction. When present, pain following a retropubic sling tends to be along the path of the sling. Most patients with mesh pain have an improvement in their symptoms following mesh excision.

*De novo* dyspareunia is also relatively rare after both types of sling, ranging from 0% to 1.6%. Pain may be an indication of mesh exposure or may suggest that the mesh is not in the correct anatomic location. Persistent pain or dyspareunia merits evaluation

with a careful vaginal examination as well as cystoscopy (to ensure there is no associated bladder or urethral erosion). Mesh-related pain is suspected if the pain can be reproduced by palpating the mesh during the physical examination. Symptoms tend to present shortly after surgery but may progressively worsen over time. During preoperative counseling, it is helpful to note that overall, sexual function improves following midurethral slings.

## *De Novo* Urinary Urgency

The overall incidence of *de novo* overactive bladder following a midurethral sling is about 9%-11%. After excluding a lower urinary tract infection, new-onset urinary urgency may be related to bladder outlet obstruction. Mild bladder outlet obstruction may be hard to detect on a urodynamic evaluation with a pressure flow study. If the patient complains of straining to void, obstruction should be on the differential diagnosis and can be managed by transecting the sling in the midline, with no removal of mesh. *De novo* urgency can also occur without any obstruction present. For patients presenting with mixed urinary incontinence, 84% will have improvement or resolution of the urgency urinary incontinence following midurethral sling placement.

## Surgical Site and Urinary Tract Infections

Preoperative antimicrobial prophylaxis, such as cefazolin, is recommended by the American College of Obstetrics and Gynecology and the American Urological Association to decrease the incidence of surgical site infections. Wound infections are uncommon, occurring in <1% of patients. Urinary tract infections occur following 3%-5% of transobturator and 10%-11% of retropubic midurethral slings. Compared to other surgical treatments for SUI, retropubic slings have the highest rate of postoperative urinary tract infection. The incidence of urinary tract infections can be decreased with early removal of the Foley catheter, keeping in mind that all patients need a trial of void prior to discharge.

# *Incontinence After Midurethral Sling*

Successful treatment of SUI has been defined using various criteria. Subjective success may be measured with a validated questionnaire. Objective success may be assessed with pad tests, a cough stress test, or urodynamic outcomes. Patient satisfaction has also been used as an important measure of success. The need for additional treatment, such as repeat surgery for SUI, is another criterion that has been used to judge surgical outcomes.

Midurethral slings are highly successful at treating SUI with similar subjective cure rates for transobturator and retropubic slings (ranging from 62% to 98%, and 71% to 97%, respectively) as well as similar objective rates between these two approaches, as noted in a Cochrane review. Some of the lowest success rates come from the highest quality studies, in part due to the stringent criteria for success used in these trials, yet these same trials note patient satisfaction scores of 85%-90%.

In a large retrospective cohort study by Wu and colleagues, <6% of women undergoing surgery for SUI alone had a subsequent surgery for SUI or pelvic organ prolapse in the next 5 years. These rates are lower than previous studies and may reflect improved long-term outcomes since the introduction of midurethral slings. Another cohort study out of Denmark by Hansen and colleagues evaluating 5820 women found a 5.7% rate of reoperation following retropubic midurethral sling and an 8.7% rate of reoperation following transobturator midurethral slings at 5 years, $P = .008$. They found no difference in reoperation rates among low-, medium-, and high-volume departments.

## Risk Factors for Surgical Failure

Hill and colleagues found that sling failure is associated with a preoperative positive cough stress test at low bladder volumes. For every additional 50 mL in bladder volume before first stress leakage, the odds of a successful sling improved 1.6-fold.

From the TOMUS trial, the odds of midurethral sling failure were 1.99-fold higher (95% CI, 1.14-3.47) with a history of prior anti-incontinence surgery and 1.89-fold higher (95% CI, 1.16-3.05) when the maximum Q-tip excursion was <30°. Failure was also more common when there was a greater complaint of urinary urgency and

for increased incontinence as determined by pad weight. Risk factors for failure were similar among both retropubic and transobturator slings. Patients with well-controlled diabetes mellitus have similar outcomes and no additional adverse events compared to nondiabetic patients.

## Evaluation and Treatment of Persistent Incontinence

When persistent incontinence is present, ensure there is no urinary tract infection and that leakage is not related to retention. Evaluate whether the symptoms are stress or urgency related. Postoperatively, untreated urgency urinary incontinence is more common than persistent SUI. When a true sling failure does occur, it is often due to being too loose or to positioning the sling in a location other than the midurethra.

If the urethra is mobile and urodynamic evaluation confirms persistent SUI without evidence of obstruction, a repeat sling may still be successful. Stav and colleagues found that retropubic slings are more successful than transobturator slings when placed after a prior sling failure but have lower success rates than primary slings. During placement of a second sling, often the prior sling is not encountered. If it is encountered at the midurethra, consider excising the vaginal portion of the first sling at the time of placement, especially if the prior sling is already occupying the midurethral position. In a retrospective study by Gaddi and colleagues out of Kaiser Permanente, only 2.4% of 6914 women underwent a repeat surgery for SUI following a midurethral sling. Repeat surgeries were either a multi-incision or single-incision sling or urethral bulking agent, with 11.2% failure following a repeat sling and 38.8% failure following urethral bulking procedures, $P = .004$. The study did not report on urethral mobility prior to the repeat procedure. If the urethra is immobile, a repeat midurethral sling is unlikely to be successful, and other therapies, such as a pubovaginal sling placed at the bladder neck or injection of a urethral bulking agent, are better options.

# Burch Retropubic Urethropexy

# History

Ward and Hilton, in their sentinel randomized trial, found that the Burch retropubic urethropexy was as effective as retropubic midurethral slings at 5-year follow-up but led to a greater number of adverse events including higher rates of bleeding, postoperative voiding dysfunction, and a longer surgical time. Thus, the Burch retropubic urethropexy is not typically preferred for the surgical treatment of SUI. However, it is an option for patients desiring surgical therapy without mesh.

The Burch urethropexy involves retropubic placement of at least two bilateral permanent suspension sutures from Cooper's ligament, anatomically known as the iliopectineal ligament, to the endopelvic fascia at the bladder neck. It can be performed open or laparoscopically, with 2-year data suggesting similar outcomes between these approaches. The Marshall-Marchetti-Krantz procedure is a similar surgery in which the suspension sutures are attached to periosteum of the pubic bone, not Cooper's ligament, but is not recommended due to the development of osteitis pubis in 0.7% of patients.

# Anatomy

This surgery is performed in the retropubic space, also known as the space or cave of Retzius, one of the potential spaces in the pelvis. Abdominally, entrance into this space is facilitated by leaving the peritoneum intact and dissecting along the reflection of the peritoneum adjacent to the pubic bone. The space is bounded anteriorly by the superior pubic rami and laterally by the obturator internus muscles and inferior pubic rami. The endopelvic fascia forms the floor of the space and is attached laterally to the arcus tendineus fascia pelvis. The proximal urethra and bladder rest on the endopelvic fascia (**FIG. 33.13**).

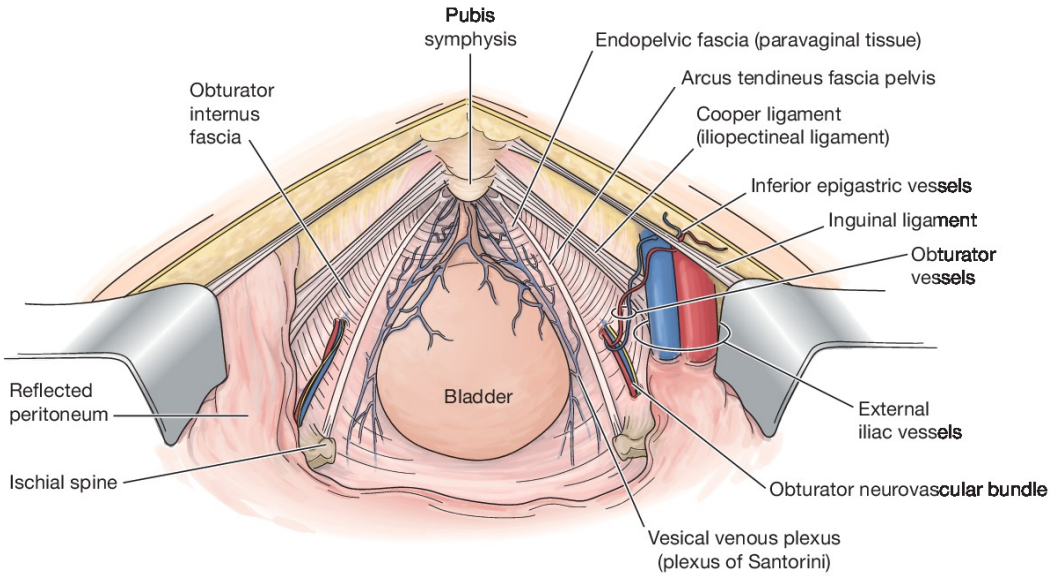


**FIGURE 33.13** Anatomic landmarks in the space of Retzius.

Several vascular structures are in close anatomic proximity. The external iliac vessels course lateral to the retropubic space. The obturator neurovascular bundle passes through the lateral aspect of the space along the obturator internus muscle and exits the pelvis through the obturator canal at the superolateral aspect of the obturator foramen. If present, the aberrant obturator vessel is a communicating vessel between the obturator vessels and the external iliac vessels that courses along the back of the superior pubic ramus. When injured, significant bleeding can occur, leading to its moniker “corona mortis,” Latin for “crown of death.” The pudendal plexus, or plexus of Santorini, courses through the paravaginal tissue and anterior to the bladder. There are also smaller iliopectineal vessels that course behind the back of the superior pubic ramus.

There is a higher failure rate following the Burch retropubic urethropexy if the patient has a low-pressure urethra or a lack of urethral mobility. Given this, assessment of urethral function with a complex urodynamic evaluation may be considered.

# *Surgical Technique*

Preoperative antimicrobial prophylaxis is recommended, such as cefazolin. The patient is placed into a dorsal low lithotomy position to allow for both abdominal and vaginal access during the procedure. The surgery was traditionally described with an open technique and can be combined with other abdominal surgery, such as an abdominal sacral colpopexy. With the shift toward minimally invasive surgery, the Burch retropubic urethropexy can be performed laparoscopically or robotically. Studies have shown higher failure rates when shortcuts are employed, such as the use of one suture instead of two on each side of the bladder neck. Moreover, although described robotically, the traditional technique of having the surgeon place the retropubic sutures with one hand, while placing the other hand vaginally to ensure appropriate placement, requires substantial modification when approached with the robot.

## Abdominal Approach

For an open abdominal Burch retropubic urethropexy, a Foley catheter is placed and an abdominal incision made. A preperitoneal dissection is performed bluntly along the back of the pubic symphysis to gain entrance into the potential space. Sharp dissection is only needed if there is scarring from a prior retropubic procedure. A malleable retractor can be used.

Anatomic landmarks are identified including the pubic bone, the arcus tendineus fascia pelvis, and endopelvic fascia. Identify and avoid the obturator neurovascular bundle. Minimize trauma to the plexus of Santorini at the endopelvic fascia. Gently sweep the bladder medially and superiorly to clear the endopelvic fascia for suture placement. This is facilitated by a vaginal finger applying counterpressure on the vaginal wall and endopelvic fascia (**FIG. 33.14**). If bleeding occurs at the plexus of Santorini, figure-of-8 sutures or clips can be helpful.

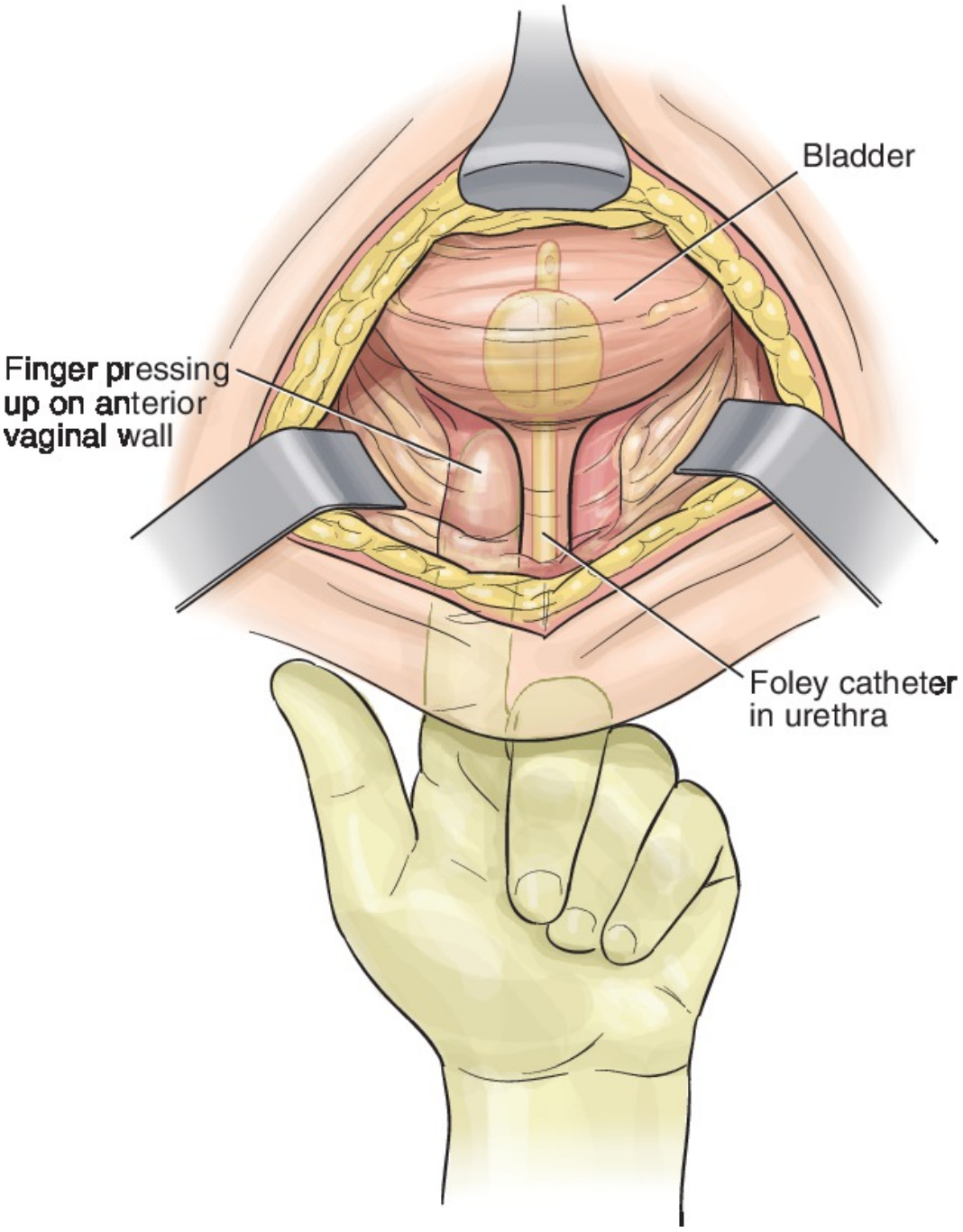


**FIGURE 33.14** Dissection of the bladder medially to expose the endopelvic fascia. The finger of the vaginal hand elevates the vagina and the surgeon places a sponge stick

abdominally, pushing the instrument medially and superiorly against the finger.

A permanent suture is placed through the endopelvic fascia at the bladder neck. The suture is placed while the surgeon places the other hand vaginally, maintaining traction on the Foley while tenting up the vaginal tissues to allow elevation of the endopelvic fascia. The surgeon places the suture at the point that is elevated by the vaginal finger, ideally 1-2 cm lateral to the bladder neck. This ensures optimal suture placement through the full thickness of the endopelvic fascia, without perforating the vaginal epithelium. A second suture is placed distal to the first, lateral to the proximal urethra. Typically, a figure-of-8 suture is placed at each location. The needle is passed through Cooper's ligament, avoiding the obturator neurovascular bundle and any aberrant obturator vessels. Ergonomically, it is easiest to place the suture through Cooper's ligament while facing the patient's head. Place two sutures on each side (**FIG. 33.15**). The sutures are tied down while an assistant has a finger in the vagina. Tie down until the assistant begins to feel a lift off the vaginal finger. These will elevate the bladder neck, but it is critical that a suture bridge remains. If tied down completely, this would overcorrect (overly lift) the bladder neck, causing bladder neck obstruction and urinary retention. Cystoscopy is performed to ensure that there are no sutures in the bladder and bilateral ureteral efflux (**BOX 33.3**).

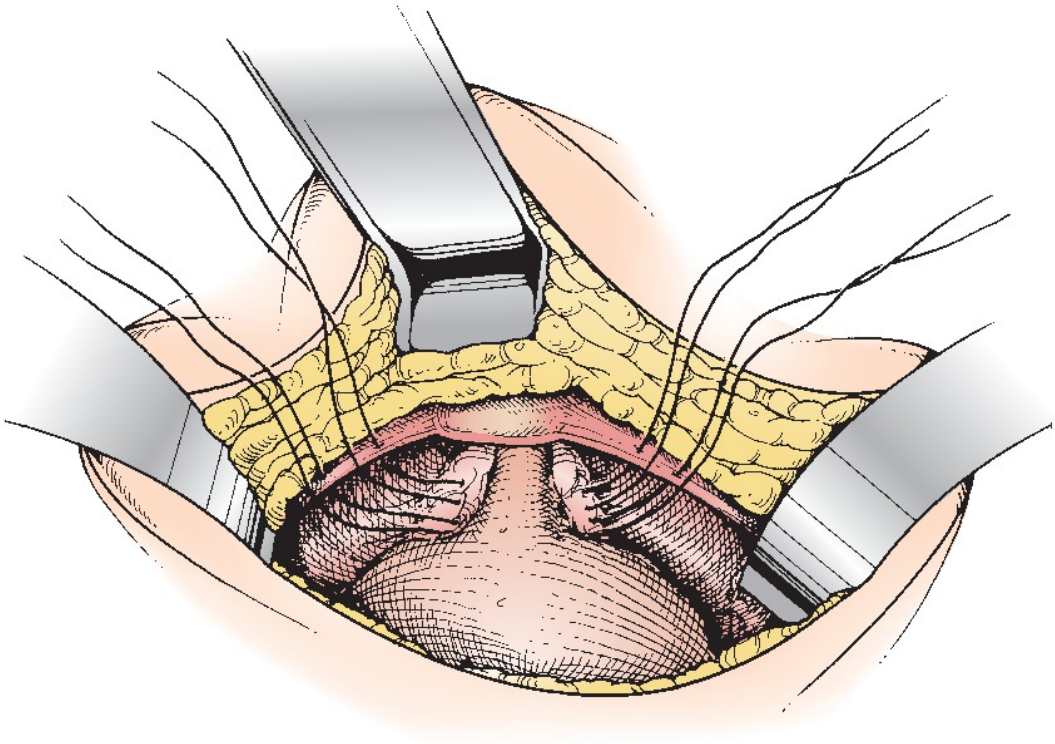

**FIGURE 33.15** Permanent sutures on either side of the bladder neck for the Burch urethropexy. The more proximal pair of sutures are lateral to the bladder neck, and the more distal pair of sutures are at the level of the midurethra. The proximal sutures are placed through the more lateral aspect of Cooper ligament with the distal sutures placed more medially.

## BOX 33.3 STEPS IN THE PROCEDURE

### Open Burch Urethropexy

- The patient is positioned in Allen stirrups.

- The bladder is drained.
- A low transverse abdominal incision is created, and the retropubic space is entered.
- The bladder neck is identified by the surgeon, with one hand in the vagina and using the Foley bulb as a guide.
- The endopelvic fascia lateral to the bladder neck is elevated with a vaginal finger, and the overlying tissue and bladder are bluntly mobilized medially and superiorly.
- Permanent sutures are placed on either side of the bladder neck, with a second pair of sutures placed at the level of the midurethra.
- One arm of each suture is placed through the ipsilateral Cooper ligament.
- Sutures are tied such that the endopelvic fascia is seen to lift slightly.
- Cystoscopy is performed.

## Laparoscopic Approach

For a laparoscopic Burch retropubic urethropexy, the umbilical port is used for the camera, two 10-mm laparoscopic ports placed in the right and left lower quadrants, and a 5-mm suprapubic port. The larger diameter ports allow direct passage of the needle used for the urethropexy sutures.

The bladder is retrograde filled via the Foley catheter, allowing visual identification of the borders of the bladder. To enter the retropubic space, a transverse peritoneal incision is made with electrocautery 2-3 cm superior to the upper pubic bone and superior to the bladder. Extend the incision laterally to the medial umbilical ligaments bilaterally and then change the angle inferiorly and posteriorly for another 1-2 cm in order to avoid the inferior epigastric vessels. At this point, the bladder is drained in order to minimize the risk of bladder injury. The cut edge of the peritoneum is pulled downward to create countertraction and visualize the areolar plane

for dissection. Blunt dissection is performed with a laparoscopic Kittner, until landmarks are seen: the superior pubic rami, the arcus tendineus fascia pelvis, and the endopelvic fascia. Avoid the obturator neurovascular bundle. The obturator neurovascular bundle courses through the obturator canal along the pelvic wall in the lateral aspects of the retropubic space. When the patient is in lithotomy, it will be located ~4 cm directly above the ischial spine. Vascular injury is avoided by keeping the dissection dorsal to these vessels and at the level of the arcus tendineus fascia pelvis. The endopelvic fascia is cleared with a Kittner laparoscopically, assisted by a vaginal hand providing elevation of on the vaginal tissues.

Permanent suture is placed in the identical location as with an open procedure. Two sutures should be placed on either side of the bladder neck, as this has improved efficacy over a single suture. A THX-26 needle for CV0 Gore-tex suture will pass down the 10-mm port. The ergonomics and visualization are improved compared to an open procedure because the camera can enter the retropubic space and provide optimal visualization, an angle that simply cannot be achieved during an open procedure. The sutures can be tied with either an intra or extracorporeal technique. Similar to an open procedure, a suture bridge is desired and an assistant is used to determine optimal tensioning, analogous to the open procedure. Cystoscopy is performed to ensure that there are no sutures in the bladder and bilateral ureteral efflux.

# *Complications*

## Intraoperative Complications

The two main intraoperative complications are bleeding or a suture in the bladder. Both are minimized by identifying anatomic landmarks and gently dissecting the endopelvic fascia free of overlying tissue. Overly aggressive traction on the endopelvic fascia can lead to bleeding from the plexus of Santorini. Elevation with a vaginal finger pulls the endopelvic tissue taught and is ideal for blunt dissection with minimal blood loss. If bleeding occurs, it can usually be managed with clips or figure-of-8 sutures. Familiarity with the vascular anatomy of the retropubic space is essential, as injury to

the obturator or aberrant obturator vessels can cause hemorrhage. Optimal dissection delineates the bladder edge and clears the endopelvic fascia and facilitates good suture placement through the endopelvic fascia while safely avoiding the bladder. The Foley balloon can be inflated with 20 mL of fluid to further assist with identification of the bladder neck. If a suture passes through the bladder, it should be removed and replaced.

### Delayed Complications

Urinary tract infections occur in 4%-8% of women, with wound infections in 7%. Temporary urinary retention is common but typically resolves spontaneously; long-term retention is rare. If there is persistent SUI, assess for urethral mobility and urinary retention. If the urethra is mobile and there is no retention, a midurethral sling can be placed following a Burch retropubic urethropexy. If the urethra is no longer mobile, consider urethrolysis with the goal of restoring mobility, a pubovaginal sling, or a urethral bulking agent.

Multiple modifications to the Burch retropubic urethropexy have been described. Attempts to use vaginal bolts, graft, or other simplifications to the procedure have typically resulted in higher complications and failures.

## Pubovaginal Sling

A pubovaginal or suburethral sling differs from a midurethral sling in that it is placed at the bladder neck and proximal urethra while elevating the urethrovesical junction via gentle traction. Often a fascial strip is used and attached to the rectus fascia with permanent sutures. During increased abdominal pressure, outward movement of the abdominal wall correspondingly lifts up and compresses the urethra.

In the Stress Incontinence Surgical Treatment Efficacy (SISTEr) trial, 655 women were randomized to undergo a Burch retropubic urethropexy or autologous rectus fascia pubovaginal sling. Success rates were higher for patients who underwent the sling in a composite evaluation of overall incontinence, with 47% success following pubovaginal slings and 38% success following the Burch

retropubic urethropexy at 24 months and 30.8% vs 24.1% overall continence at 5 years, respectively. SUI-specific success rates were 66% vs 49%, favoring pubovaginal slings at 24 months. At 5 years, 83% of women undergoing a pubovaginal sling reported satisfaction with their continence compared to 73% of women undergoing a Burch retropubic urethropexy, $P = 0.04$. This benefit was offset by greater morbidity following pubovaginal slings, including a 6% rate of voiding dysfunction leading to surgical revision, which was not seen among the Burch procedures.

Pubovaginal slings can be performed with a variety of materials, most commonly autologous fascia from the rectus sheath or fascia lata, or a synthetic implant. If permanent mesh is used, type I macroporous polypropylene is preferred. Polyester (Mersilene) has a high rate of erosion necessitating surgical removal and is not recommended. Due to the braided nature of polyester, it becomes colonized with bacteria after vaginal exposure, with resultant retropubic infection. Biologic allografts and xenografts are less commonly used due to the associated inflammatory response and concern for poorer outcomes.

Pubovaginal sling may be considered for a patient with severe SUI and an immobile urethra. In contrast, among patients with a mobile urethra, a meta-analysis by Schimpf et al. noted improved subjective outcomes and less operative time, blood loss, retention, and overactive bladder symptoms with retropubic midurethral slings compared to pubovaginal slings, but inadequate data to determine any differences with objective success rates.

Preoperative prophylactic antimicrobial therapy is recommended, such as cefazolin. A transverse abdominal incision is made two fingerbreadths above the pubic symphysis (**FIG. 33.16**). Once the fascia is dissected clear, the planned allograft measurements are inked, with a goal of harvesting at least 10 cm in length by 2 cm in width, staying two fingerbreadths superior to the symphysis. If less tissue is harvested, then a patch sling can be performed but will have lower efficacy and is not recommended. The fascia is kept in sterile saline until use later in the procedure. The fascial defect is undermined to minimize tension on the closure and then sutured close.

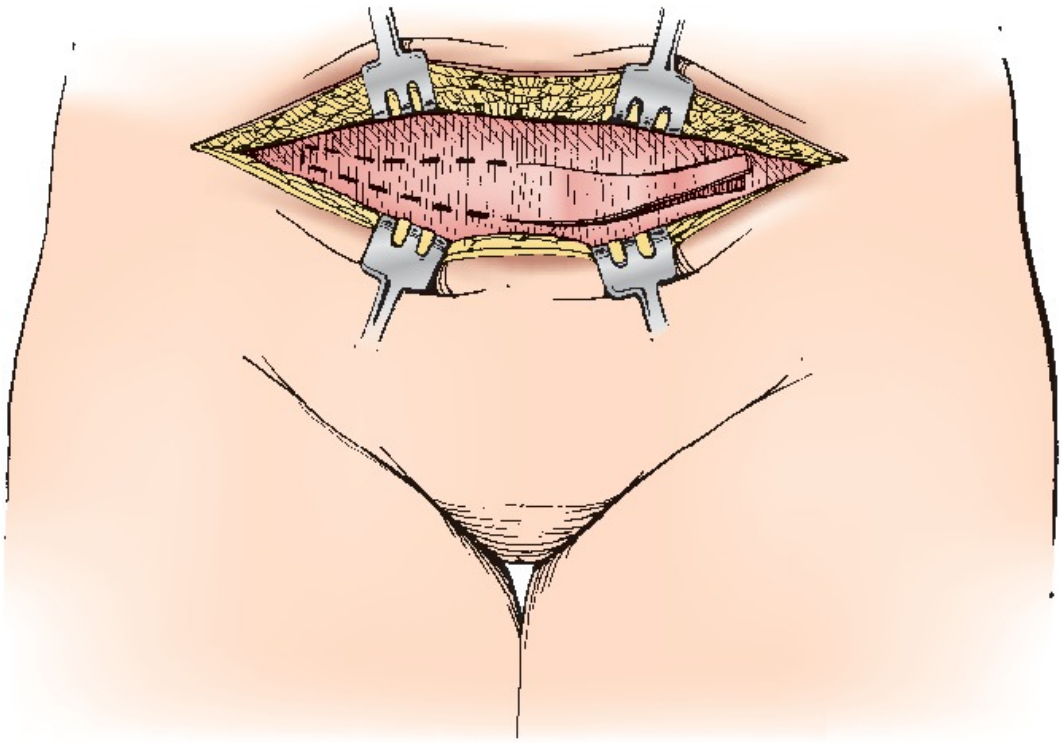

**FIGURE 33.16** Incision for harvest of rectus fascia.

Vaginally, a vertical incision is made at least 3 cm in length, centered on the bladder neck. Dissect the vaginal epithelium off of the endopelvic fascia until the dissection reaches laterally and is under the inferior pubic ramus. The bladder is decompressed, and the urethrovesical junction is identified by placing gentle traction on the Foley catheter. The urethra is protected and displaced with the surgeon's nondominant hand, while simultaneously perforating the endopelvic fascia with Metzenbaum scissors, staying lateral to the urethra, directly behind the symphysis, adjacent to the inferior pubic ramus, while aiming toward the ipsilateral shoulder. This allows entrance into the retropubic space. Digital blunt dissection then clears the retropubic fat away from the bone (**FIG. 33.17**).

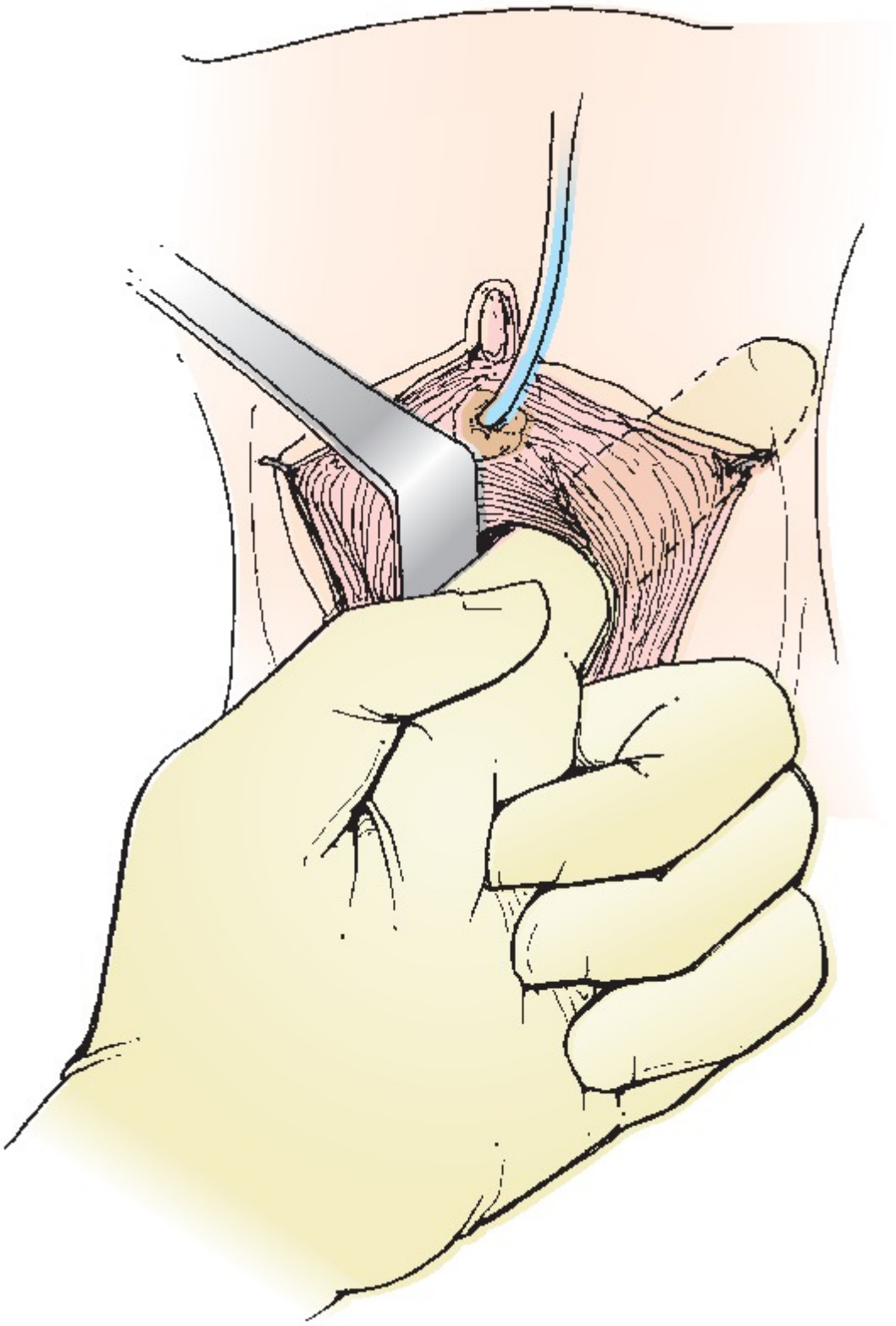

**FIGURE 33.17** Perforation of the endopelvic fascia to open the space of Retzius and

mobilize the periurethral tissues.

Abdominally, packing forceps or a long tonsil clamp is placed along the superior aspect of the pubis, 2 cm lateral to the midline, perforating through the abdominal wall fascia and passing through the retropubic space with guidance from the surgeon's vaginal finger (**FIG. 33.18**). The fascial arm is then grasped by the packing forceps and pulled abdominally. This is repeated on the contralateral side. If the sling arms will not reach the abdominal wall fascia, permanent sutures are passed through the tail of each arm and brought up to the abdomen. Cystoscopy is performed to ensure no bladder or ureteral injury.

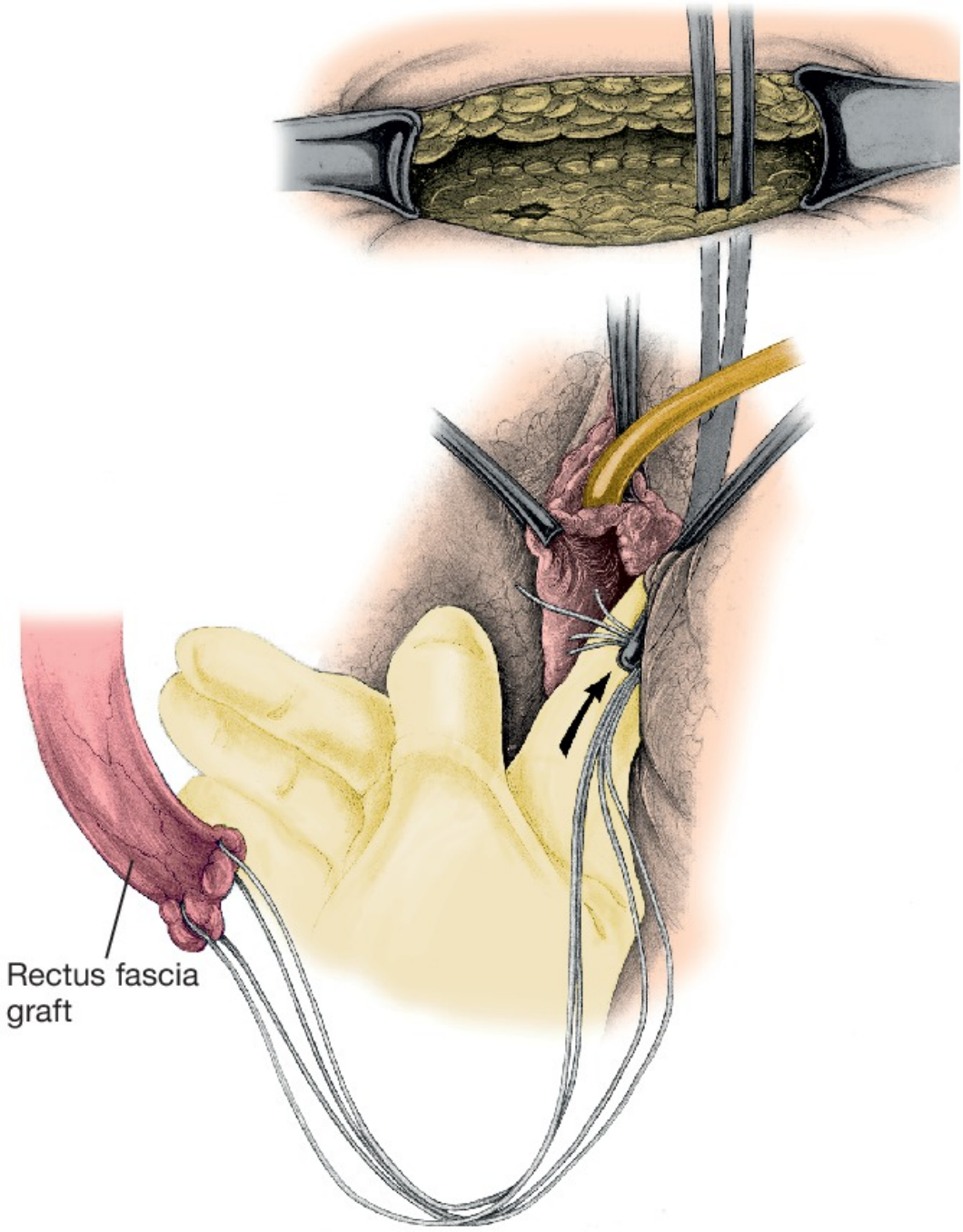


**FIGURE 33.18** Passage of sling material through the space of Retzius from vaginal to abdominal site. Rectus fascia partial sling with attached sutures.

Vaginally, the sling is sutured under the bladder neck and proximal urethra. Placement under the urethra can result in obstruction while placement under the bladder can result in persistent incontinence. Given the benefits of midurethral slings on postoperative voiding dysfunction, some surgeons have started placing their fascial slings at the midurethra; however, if the urethra is immobile, then a bladder neck location is recommended. The sling arms are then sutured to the rectus fascia (**FIG. 33.19**) or over the fascia by tying the suspension sutures together. Slight tension is achieved by tying over an assistant's finger or placing a cotton swab in the urethra and tying until the urethrovesical junction is at a 0° angle with the horizontal plane. The remaining abdominal and vaginal incisions are closed with delayed absorbable suture. Patients are typically kept overnight with a Foley catheter, followed by a trial of void (**BOX 33.4**).

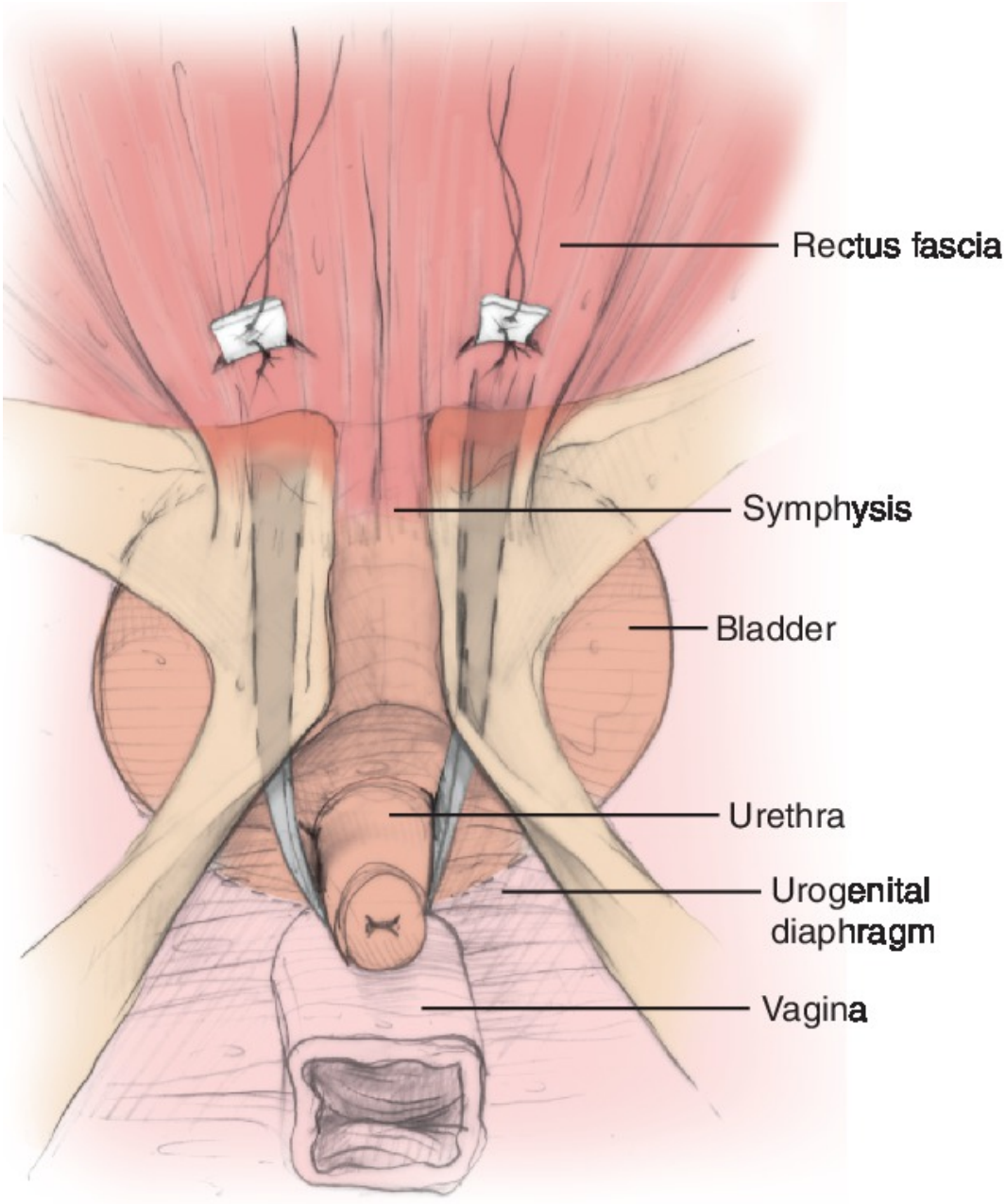


**FIGURE 33.19** Sling positioned at proximal urethra, extending through the space of Retzius, and fixed to the rectus fascia.

## BOX 33.4 STEPS IN THE PROCEDURE

## Suburethral Sling

- The patient is positioned in Allen stirrups. A Foley catheter is placed, and the bladder is drained.
- A suprapubic transverse abdominal incision is made and continued to the fascia. The surgeon may elect to harvest rectus fascia at this point.
- Subcutaneous fat is cleared from the surface of the fascia at the location where the sling arms (or sutures) will be passed through the fascia (above the symphysis and 2 cm lateral to the midline).
- A midline vaginal incision is created, and the vaginal epithelium is dissected off the endopelvic fascia to the inferior pubic ramus.
- The surgeon enters the retropubic space and uses a finger to mobilize the bladder and retropubic fat medially and superiorly.
- A long pair of packing forceps is inserted via the abdominal incision, perforating the rectus and entering the retropubic space. The surgeon's finger, placed into the retropubic space via the vagina, meets the advancing clamp (minimizing the potential risks of blind passage).
- Each sling arm is thus passed from the vaginal to the abdominal field. The central portion of the sling is tacked to the bladder neck to prevent movement from the placement site.
- Tension on the sling arms is adjusted. If the sling is of sufficient length, the sling arms are sutured to the rectus fascia. If the sling is not sufficiently long, permanent sutures, placed through the end of each sling arm, are sutured to the rectus fascia.
- Cystoscopy is performed.

# *Complications*

## Intraoperative Complications

The main intraoperative complications are retropubic bleeding or bladder perforation. Retropubic bleeding is best managed with pressure. Cystoscopy is essential for this procedure and may also be used to assess for bladder outlet obstruction if the sling is too tight. Bowel perforation can occur if the dissection does not remain in the space of Retzius and the peritoneal cavity is breached.

### Postoperative Complications

Urinary tract infections occur in about 4% of patients and wound infections in 3%. Voiding dysfunction is common following this procedure, and patients need to be appropriately counseled about the relatively high rate of urinary retention. Patients should be advised that they may require clean intermittent self-catheterization following the surgery. More subtle bladder outlet obstruction may manifest as *de novo* urgency. Incomplete bladder emptying can lead to recurrent urinary tract infections. In the SISTEr trial, 6% of women required surgical revision of their pubovaginal sling due to retention.

In the SISTEr trial, 25% of women with a pubovaginal sling had a wound complication, 3% of which necessitated surgical intervention, similar to that seen in the Burch retropubic urethropexy arm of the study. Hematoma formation can contribute to problems with wound healing and increases the risk of subsequent abscess. If a permanent mesh is used, vaginal exposure may occur.

At 5-year follow-up for the SISTEr trial, fewer women with a pubovaginal sling underwent surgical retreatment compared to those undergoing a Burch retropubic urethropexy, 2% vs 12%, $P < 0.0001$.

## Urethral Bulking Agents

Urethral bulking agents can be injected deep to the urethral mucosa at the level of the bladder neck. While the concept of a minimally invasive procedure resulting in improved coaptation of the urethral lumen is attractive, this technique has higher failure rates compared to other surgical interventions. Cure rates have been reported in 24.8%-36.9% of patients at 1-year follow-up, and repeat injections are often needed. Rates of improvement are higher, up to 70%, but degree of improvement is difficult to quantify. It can be a successful

option in patients with an immobile urethra who are not good candidates for a midurethral sling.

The ideal material for urethral bulking would be biologically well-tolerated, easy to inject, not migrate, and have long-lasting success. This has been difficult to achieve. There is merit in a brief history of these materials as understanding prior challenges underscores the need for high-quality long-term data. One of the first commonly used agents was cross-linked bovine collagen. A biologic agent, it was generally well tolerated but degraded over time and lacked longevity. Autologous fat was discontinued due to devastating pulmonary fat embolisms. It also suffered from rapid breakdown and had similar efficacy to saline placebo. Desiring better longevity, permanent particulate materials have been tried. Carbon-coated beads have been in use for over two decades, but the beads can migrate to the lymphatics and injecting the material can be technically challenging. Polydimethylsiloxane silicone permanent particles have been well tolerated at 3 years. There are case reports of urethral exposures, often associated with recurrent urinary tract infections or irritative bladder symptoms. Other agents have had postmarket complications leading to discontinuation, such as high rates of urethral erosion after vinyl alcohol copolymer bulking. In an effort to optimize biocompatibility, biodegradable options have been used. Calcium hydroxylapatite particles are chemically similar to bone suspended in a gel carrier. As such, it degrades very slowly and repeat injections were less common compared to collagen. Usually well tolerated, there are case reports of large urethral mucosa prolapse following these injections.

Hyaluronic acid with dextranomer, also biocompatible and biodegradable, had an excellent safety profile for pediatric reflux but was withdrawn from the market for urethral bulking given a high incidence of pseudo-abscess formation. In late 2020, the FDA approved cross-linked polyacrylamide hydrogel, a permanent nonparticulate material that had been used for many years in Europe before being available in the United States. It is also supported by 7-year safety data and randomized trials comparing it to retropubic midurethral slings, as detailed below.

Currently available products in the United States include pyrolytic carbon-coated beads (Durasphere [Coloplast; Minneapolis, MN]), polydimethylsiloxane silicone particles (Macroplastique [Cogentix Medical; Minnetonka, MN]), calcium hydroxylapatite (Coaptite [Boston Scientific; Marlborough, MA]), and a cross-linked polyacrylamide hydrogel (Bulkamid [Axonics; Irvine, CA]).

Only one agent, Bulkamid, has been compared to midurethral slings in a randomized trial. At 3 years, there were higher satisfaction and cure rates with the retropubic sling, balanced by fewer complications with Bulkamid. The subjective cure was only 25% with Bulkamid vs 60% with midurethral slings. When improvement (not just cure) was analyzed, 89% of women had improvement with Bulkamid compared to 100% following a midurethral sling. Need for repeat injections was common and 28% of women randomized to Bulkamid crossed over to a midurethral sling, versus 3% of crossover among slings. Complications were infrequent with Bulkamid in this trial, with acute urinary retention in 3% compared to 10% for midurethral slings. Bladder perforations, hematoma, extrusion, and reoperation for complication occurred with the slings only. There is a theoretic concern regarding intravascular injection and possible embolism with Bulkamid. Given this, vessels near the site of injection need to remain visible during the procedure to minimize risk of necrosis. Bulkamid is also supported by 7-year data from a case series of 1200 women, with no severe adverse events reported among the 32% who remained in the study.

A transurethral approach via cystoscopy is described here (**FIG. 33.20**), although injections can also be performed periurethrally. This approach can be used for Durasphere or Coaptite. Ensure that the patient does not have a urinary tract infection. The procedure can be performed in the office or the operating room. For an office procedure, anesthetic can be with a transurethral lidocaine gel, a paraurethral block, or both. Routine prophylactic antibiotics are not indicated. A 12° or 30° cystoscope is advanced into the bladder and the needle passed through the working port. The needle is primed with the agent to be injected. With sterile water or saline flowing to distend the urethra and optimize visualization, the scope and needle are pulled ~2 cm back into the urethra. The needle is injected at 3

o'clock at a 45° angle until the bevel of the needle is covered in tissue, and then the angle is changed to be parallel with the urethra and advanced to the proximal urethra. The bulking agent is injected slowly and then the needle held in place for an additional few seconds to minimize extravasation of the implant. This is repeated at the 9 o'clock position (**FIG. 33.21**; **BOX 33.5**). The scope is removed. Urinary retention can occur, so the patient should demonstrate the ability to void prior to discharge. Postprocedure irritative voiding symptoms can be managed with phenazopyridine (Pyridium) (**BOX 33.5**).

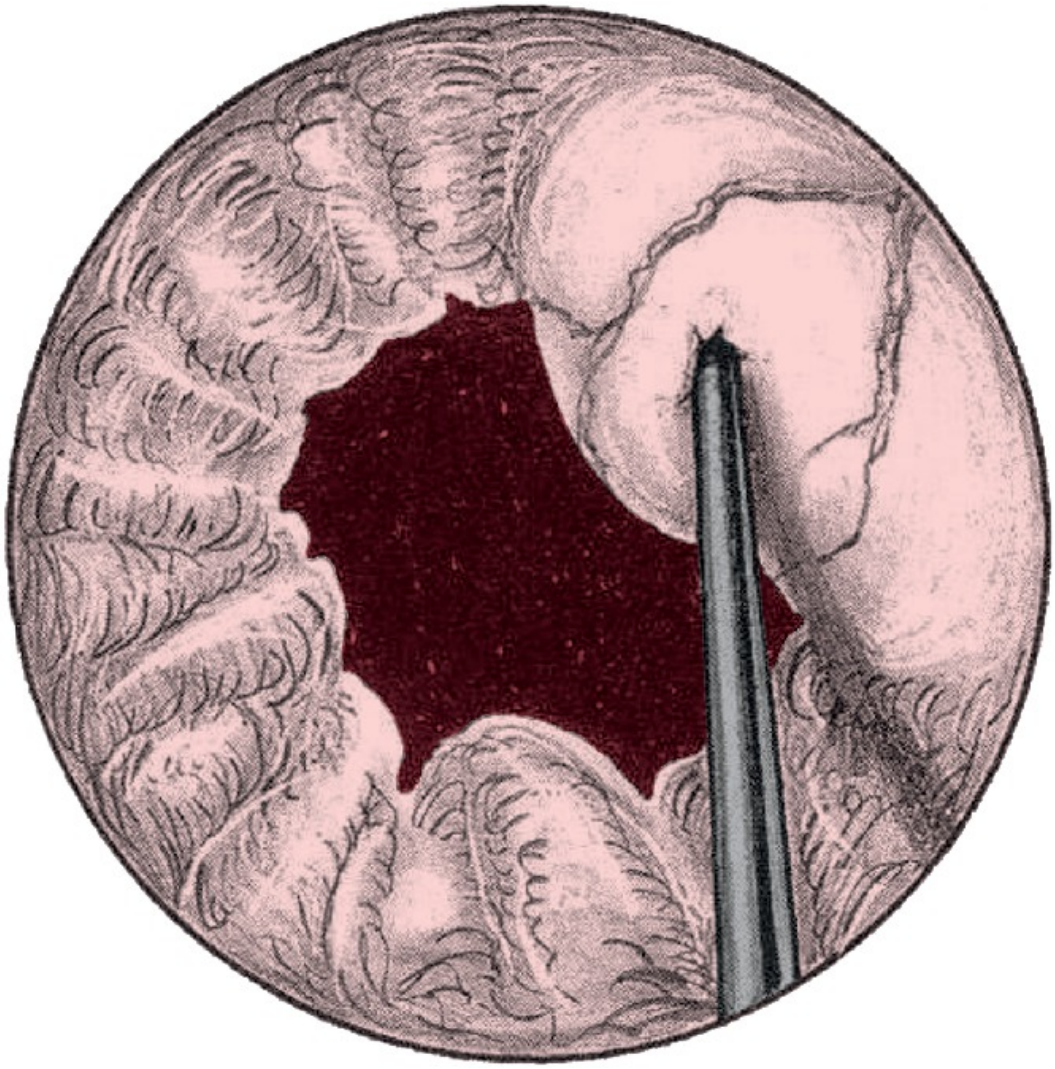

**FIGURE 33.20** Transurethral needle placement in urethral submucosa. (Reprinted from Bent AE. Periurethral collagen injections. *Oper Tech Gynecol Surg*. 1997;2:54. Copyright © 1997 Elsevier. With permission.)

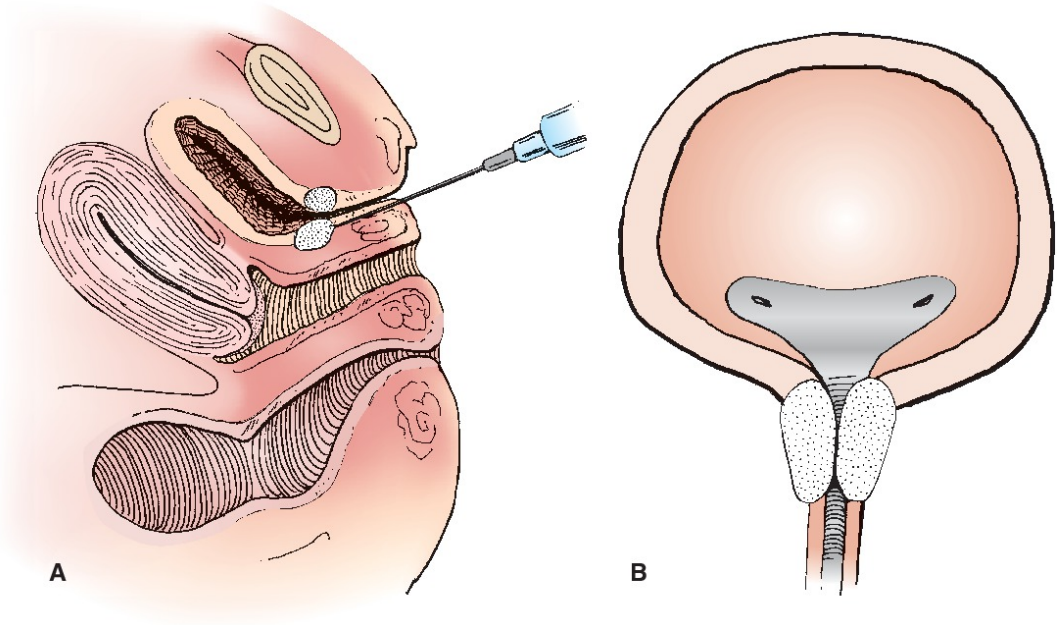


**FIGURE 33.21** **A.** Periurethral injection at the bladder neck. **B.** Bulking of bladder neck and proximal urethra.

## BOX 33.5 STEPS IN THE PROCEDURE

### Transurethral Injection of Bulking Agent

- This procedure may be done in the office or operating room.
- The patient empties her bladder and is placed in the lithotomy position.

- Topical anesthetic gel can be applied to the urethra.
- Using a cystoscope with a 12° or 30° lens, the urethra is inspected. The bladder neck is identified, and the scope is withdrawn to visualize the proximal urethra.
- The desired bulking agent is injected via an appropriate needle (usually 18- to 21-gauge), ~2 cm distal to the bladder neck.
- The usual injection sites are 3 and 9 o'clock.
- Bulking material is injected until visible closure and coaptation of the urethral lumen.
- A voiding trial should be performed before the patient leaves the clinic. This can be facilitated by leaving the bladder comfortably full at the conclusion of the procedure.

Both Macroplastique and Bulkamid have their own proprietary injection device. The manufacturer for Macroplastique recommends three injections starting at the 6 o'clock position and then repeating at 10 and 2 o'clock. Flow is controlled by squeezing the trigger of the high-pressure administration device. Bulkamid uses a short female cystoscope and is injected with the needle parallel against the urethral wall (no angling of the needle). Bulkamid has specific guidelines to ensure consistent delivery of the bulking agent among clinicians.

## *Complications*

If the needle is not placed correctly, it may perforate through the bladder neck and inject the material in the bladder lumen, leading to wasted material and no therapeutic benefit. If extravasated material is seen, stop the injection and reposition the needle. Some companies have created needles with a side opening, allowing the injection to occur deep to needle placement. Both Macroplastique and Bulkamid note a risk of intravascular administration. Other adverse events include urinary retention, urinary tract infection, hematuria, de novo urgency urinary incontinence, extrusion of the bulking agent, immune reactions, and granuloma formation. If the

patient is unable to void, a pediatric 8 French Foley catheter may be placed overnight or the patient may perform clean intermittent self-catheterization with an 8- to 12-French catheter. Minimal manipulation and a small catheter are used in order to minimize deforming and displacing the bulking agent.

A repeat injection is often needed. Typically, repeat injections are only offered after 4 weeks. If good benefit does not occur after two injections, other treatment options may be reconsidered, although there is no absolute upper limit on the number of times a bulking agent can be administered. Excessive injection of implants into the urethra may increase the risk for an adverse event and may compromise the effectiveness of other surgical approaches.

# SURGICAL TREATMENT OF MIXED URINARY INCONTINENCE

Compared to those presenting with stress urinary incontinence, patients with mixed urinary incontinence are a more complex population to treat. While symptoms of overactive bladder would be expected to persist after surgical treatment of stress incontinence, multiple studies show a carry-over benefit of midurethral sling on overactive bladder symptoms for some patients. In the Effects of Surgical Treatment Enhanced with Exercise for Mixed urinary incontinence (ESTEEM) trial, patients with mixed incontinence were randomized to midurethral sling with or without behavioral and pelvic floor muscle therapy. Outcomes were similar between groups. A secondary analysis found that 29.6% had persistent incontinence at 1 year. Only half of the failures needed additional treatment for incontinence and 96% of all retreatment was for overactive bladder, not SUI. Thus, patients with significant baseline overactive bladder should be counseled that additional therapies may be needed post-midurethral sling to address urgency-related incontinence. Another trial randomized intradetrusor onabotulinumtoxinA or saline injections at the time of retropubic midurethral sling among patients with mixed urinary incontinence. They found less severe urgency

symptoms at 3 months, but no difference in overall incontinence at 3 months.

# OCCULT SUI

Occult SUI is a phenomenon in which pelvic organ prolapse obstructs the urethra, thus masking the presence of underlying SUI. This phenomenon is thought to be responsible for the “unmasking” of SUI after prolapse surgery in 25%-42% of patients. Of these, a third report being moderately or greatly bothered by the incontinence. Continent patients undergoing surgical repair of prolapse should be counseled about the potential for occult SUI.

Surgery for SUI can be performed at the time of surgery for prolapse and will typically prevent the emergence of SUI symptoms after prolapse is corrected. However, the benefits of preventing occult SUI need to be balanced with the risks of additional surgery and potential obstruction, keeping in mind that patients may be less accepting of adverse consequences following a prophylactic procedure.

There are three different approaches to considering and managing occult SUI, and the approach taken may vary according to the preferences and concerns of an individual patient. One option is to assess for occult SUI preoperatively, using this information to help guide decision-making about a prophylactic continence procedure. This can be done with prolapse reduction during a cough stress test or urodynamic evaluation or by having the patient wear a pessary. Another approach is to offer a second, staged surgery if bothersome incontinence presents after correction of the prolapse. The third approach is to empirically perform a continence surgery on all patients undergoing prolapse repair. The latter option has been assessed with randomized trials. Brubaker and colleagues found that a concomitant Burch retropubic urethropexy at the time of an abdominal sacral colpopexy decreased bothersome SUI, with 6.1% SUI following a Burch and 24.5% among controls, with no difference in adverse events or morbidity, other than increased surgical time to perform the Burch procedure. Wei and colleagues, in an analogous study for vaginal surgery assessing outcomes following a

prophylactic midurethral sling at the time of vaginal prolapse repair, found that the prophylactic sling reduced postoperative urinary incontinence from 43% in controls to 27.3% in women undergoing a sling. This corresponds to needing to treat 6.3 patients with a prophylactic sling in order to prevent one case of urinary incontinence. Those undergoing a midurethral sling also had a higher incidence of adverse events (6.7% risk of bladder perforation with midurethral sling vs 0% in controls, 31% rate of urinary tract infection vs 18.3%, major bleeding in 3.1% vs 0%, respectively). In the year following the prolapse surgery, 2.4% of women with a sling had urinary obstruction requiring sling revision, while 4.7% of women without a sling opted for an anti-incontinence procedure. These studies highlight the prevalence of occult SUI and that both the potential benefits of a prophylactic procedure as well as the harms must be taken into account.

# KEY POINTS

- SUI is a common condition.
- Counseling about effective treatment options includes discussion of both conservative and surgical therapies. At 1 year, over 50% of patients are satisfied with the outcome of nonsurgical therapy.
- Midurethral slings should be the first-line surgical therapy due to their high success rate and low morbidity. They are the most extensively studied surgery for SUI.
- The medical literature, the United States Food and Drug Administration (FDA), and numerous medical associations have affirmed the safety and effectiveness of transvaginal mesh in midurethral slings for the treatment of SUI.
- Other highly effective surgical options for the treatment of SUI include Burch retropubic urethropexy or a pubovaginal sling with autologous fascia. Patients should be informed that these procedures are associated with a longer recovery time, more

blood loss, and more postoperative voiding dysfunction than midurethral slings.

- A complex urodynamic evaluation is not needed for every patient with stress urinary incontinence (SUI) seeking surgical treatment with a midurethral sling. A basic office evaluation will be sufficient for most patients with uncomplicated, objectively confirmed SUI who have stage II or less pelvic organ prolapse, urethral mobility, a postvoid residual <150 mL, and no prior anti-incontinence surgery.
- Success rates with urethral bulking agents are inferior to other surgeries; however, they may be a good choice if there is minimal urethral mobility or the patient is a poor surgical candidate.
- Cystoscopy should accompany all surgical treatment for SUI.

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# CHAPTER 34

# COLPOCLEISIS

Melinda G. Abernethy

**Special Considerations for Obliterative Procedures**

**Preoperative Evaluation**

Preoperative Assessment of Older Patients With Pelvic Organ Prolapse

Endometrial/Cervical Surveillance prior to Le Fort Colpocleisis

Evaluation for Hydroureter in Patients With Severe Prolapse

Preoperative Evaluation for Occult Stress Incontinence

**Consideration for Concomitant Hysterectomy**

**Le Fort Colpocleisis**

**Colpectomy/Colpocleisis**

**Concomitant Levator Myorrhaphy and Perineorrhaphy**

**Perioperative and Postoperative Considerations**

Complications

Intraoperative Cystoscopy

Success/Failure Rates

Regret/Sexual Function

Between 2012 and 2050, the population of adults aged over 65 years is projected to double to an estimated 83.7 million, with women accounting for 63%. Over that same interval, the oldest-age group

(>85 years) is expected to triple in size, reaching over 18 million. Thus, the number of women over 65 years of age who undergo elective surgery is expected to rise. In fact, patients over the age of 65 currently constitute over half of the average general surgical practice.

Similarly, the prevalence of age-related chronic conditions, including pelvic floor disorders, will increase. Based on our most current population data, it is estimated that ~50% of women aged 80 years of age have experienced at least one pelvic floor disorder. Using census projections, we could estimate that by 2050, ~9 million women in their eighth decade would have experienced a pelvic floor disorder.

Although surgery is often elected for management of symptomatic pelvic organ prolapse, all patients should be offered a pessary as first-line therapy. Pessaries can be successfully fitted in ~75% of cases. Pessary users typically experience improvements in physical functioning, general well-being, and body image. However, even among those successfully fitted, vaginal complications, as well as the burden of additional health care visits, will lead some patients to elect surgical repair.

Healthy older patients are likely to tolerate surgery but are at a higher risk for perioperative complications due to age-related physiologic changes including reduced renal and lung function and impaired left ventricular compliance. Patients older than 65 years are more likely to experience perioperative complications including infection, need for blood transfusions, cardiovascular events, and need to undergo reoperation. Among patients undergoing urogynecologic surgery, those over the age of 80 years have more than 10 times the risk of death compared to younger patients.

For some patients, vaginal obliterative procedures provide an excellent option for surgical repair of pelvic organ prolapse. Colpectomy/colpocleisis and the Le Fort partial colpocleisis are both minimally invasive procedures that effectively obliterate the vaginal canal. Under discretion of the anesthesiology team, both procedures can be performed under either general or regional anesthesia. For older patients, regional anesthesia is associated with a reduction in the incidence of deep vein thrombosis and 30-day overall mortality.

Furthermore, colpocleisis procedures typically avoid entry into the peritoneal cavity and can typically be completed in less time than many vaginal reconstructive procedures, thereby limiting the time that patients are in the operating room and reducing the risks of cardiovascular and venous thromboembolic events, electrolyte abnormalities, and neuropathies.

## SPECIAL CONSIDERATIONS FOR OBLITERATIVE PROCEDURES

After colpocleisis, vaginal penetrative intercourse is typically no longer feasible, and the patient must be sure that she is no longer interested in this activity. This does not mean that patients cannot engage in sexual interactions after colpocleisis, as some older women report fulfilling sexual lives that do not require or include vaginal penetration. According to a large national study, ~25% of sexually active women between 75 and 85 years of age do not engage in vaginal intercourse. However, in addition to the altered function of the postoperative vagina, patients should also be counseled on the changed anatomy and how that may affect their sense of sexuality. In addition, after obliteration of the vaginal canal, cervical cytologic screening and transvaginal ultrasound are no longer feasible. Therefore, the ideal candidate for colpocleisis is not at high risk for the development of vaginal, cervical, or endometrial pathology and does not have adnexal pathology requiring transvaginal ultrasound surveillance. While many patients elect colpocleisis because they are poor candidates for more invasive reconstructive surgeries, vaginal obliterative surgery remains an option for any well-counseled woman who understands the associated risks and benefits.

The majority of women who undergo colpocleisis have advanced stage pelvic organ prolapse, typically stage IV based on POP-Q criteria. The procedure is technically easiest among women with symmetric degrees of anterior and posterior wall eversion, which allows for the most straightforward repair. While it is possible to perform vaginal obliterative surgery on women with less severe or

asymmetric prolapse, it is a more challenging operation in this setting and may not result in optimal outcomes.

# PREOPERATIVE EVALUATION

## Preoperative Assessment of Older Patients With Pelvic Organ Prolapse

Preoperative comorbidities such as congestive heart failure, coronary artery and peripheral vascular disease, chronic obstructive pulmonary disease, hypertension, renal impairment, and diabetes are more prevalent among the elderly population and must be taken into consideration in preoperative planning. Older patients should therefore receive a thorough preoperative evaluation to optimize management of comorbidities. Given the prevalence of cognitive impairment and dementia among older patients, it may be helpful to include a preoperative assessment of cognitive status in patients over 65 years. Cognitive decline is associated with higher risks of postoperative delirium and subsequently affects surgical outcomes, functional status, and mortality. Similarly, an assessment of decision-making capacity may be important prior to surgical counseling and consent signing. Functional status, or the ability to perform daily activities, is highly associated with postoperative outcomes. Among patients older than 80 years of age, functional status is a stronger predictor of 30-day mortality than is age alone. An assessment of frailty, evaluation of nutritional status, medication optimization, assurance of a social support system, and the verification of an advance directive and designated medical decision maker are also important aspects of preoperative preparation for this patient population.

## Endometrial/Cervical Surveillance Prior to Le Fort Colpocleisis

As previously noted, surveillance for pathology of the cervix and uterus is severely limited after Le Fort colpocleisis. Among patients with a complaint of postmenopausal bleeding, preoperative evaluation should confirm the absence of uterine and cervical pathology. For patients who require surveillance of upper tract pathology, such as patients with a history of preinvasive conditions of the cervix or endometrium, an alternative surgical approach should be considered.

In contrast, among asymptomatic, low-risk patients, cervical cytologic screening is not routinely recommended after the age of 65 years. Given the low rates of human papillomavirus infection among this population of patients, routine preoperative cervical screening is not necessary.

In addition, routine preoperative endometrial evaluation, with either transvaginal ultrasound or endometrial biopsy, is not cost-effective for low-risk, asymptomatic patients. In preparation for Le Fort colpocleisis, the cost of performing universal ultrasound or endometrial biopsy to detect one case of occult endometrial cancer would be $1.8 million and $750 000, respectively. However, given that it is difficult after Le Fort colpocleisis to evaluate symptoms such as postmenopausal bleeding, most pelvic floor surgeons recommend preoperative transvaginal ultrasound to evaluate the endometrium and adnexa. For patients with an endometrial stripe of <5 mm, the surgeon can typically be reassured of the absence of uterine pathology. In cases of a thickened endometrial stripe, further evaluation is recommended. This may be accomplished with a preoperative endometrial biopsy or a concomitant dilation and curettage at the time of colpocleisis. Surgeons who perform dilation and curettage at the time of Le Fort should recognize that the probability of diagnosing occult atypical, precancerous, or malignant pathology is <1% in this setting. Furthermore, any abnormal finding would be evident only postoperatively, resulting in the possible need for additional surgery.

## Evaluation for Hydroureter in Patients With Severe Prolapse

Among those with severe uterine prolapse, it may be helpful for patients to undergo preoperative radiologic evaluation to identify hydronephrosis or hydroureter prior to surgical repair. While its presence would not necessarily alter the surgical plan, acknowledgment of hydronephrosis and subsequent evaluation of renal function may be useful for following renal function postoperatively and guiding perioperative medical management.

# Preoperative Evaluation for Occult Stress Incontinence

Occult stress incontinence is discussed in Chapter 33. While the prevalence of occult stress incontinence among patients undergoing vaginal obliterative procedures may be as high as 48%-78%, data to support the routine placement of a prophylactic midurethral sling are limited. Many surgeons recommend that preoperative urodynamic testing be considered to evaluate for occult stress incontinence. However, an alternative is to ask the patient to perform a Valsalva maneuver with the prolapse reduced and with a comfortably full bladder.

Chronic urinary retention is common among patients with severe uterovaginal prolapse and especially among those of advanced age. Thus, the surgeon may hesitate to recommend a prophylactic midurethral sling in the setting of incomplete bladder emptying. However, despite of the high prevalence of incomplete bladder emptying among patients undergoing colpocleisis, postoperative rates of retention and voiding dysfunction (postvoid residual volumes of >100 mL) are low, even with the placement of a concomitant midurethral sling. In fact, most patients with chronic urinary retention will experience a normalization of their bladder emptying following repair of their advanced prolapse. Preoperative urinary retention should therefore not prevent surgeons from recommending a concomitant procedure for the treatment of stress urinary incontinence or prevention of occult stress incontinence.

As with other prolapse surgeries, the discussion regarding a staged vs. concomitant sling procedure should be patient centered,

accounting for individual perceptions and preferences. After colpocleisis, rates of postoperative *de novo* urinary urgency and/or frequency appear to be low, ranging from 0% to 15% in most studies, and are not increased with concomitant sling placement.

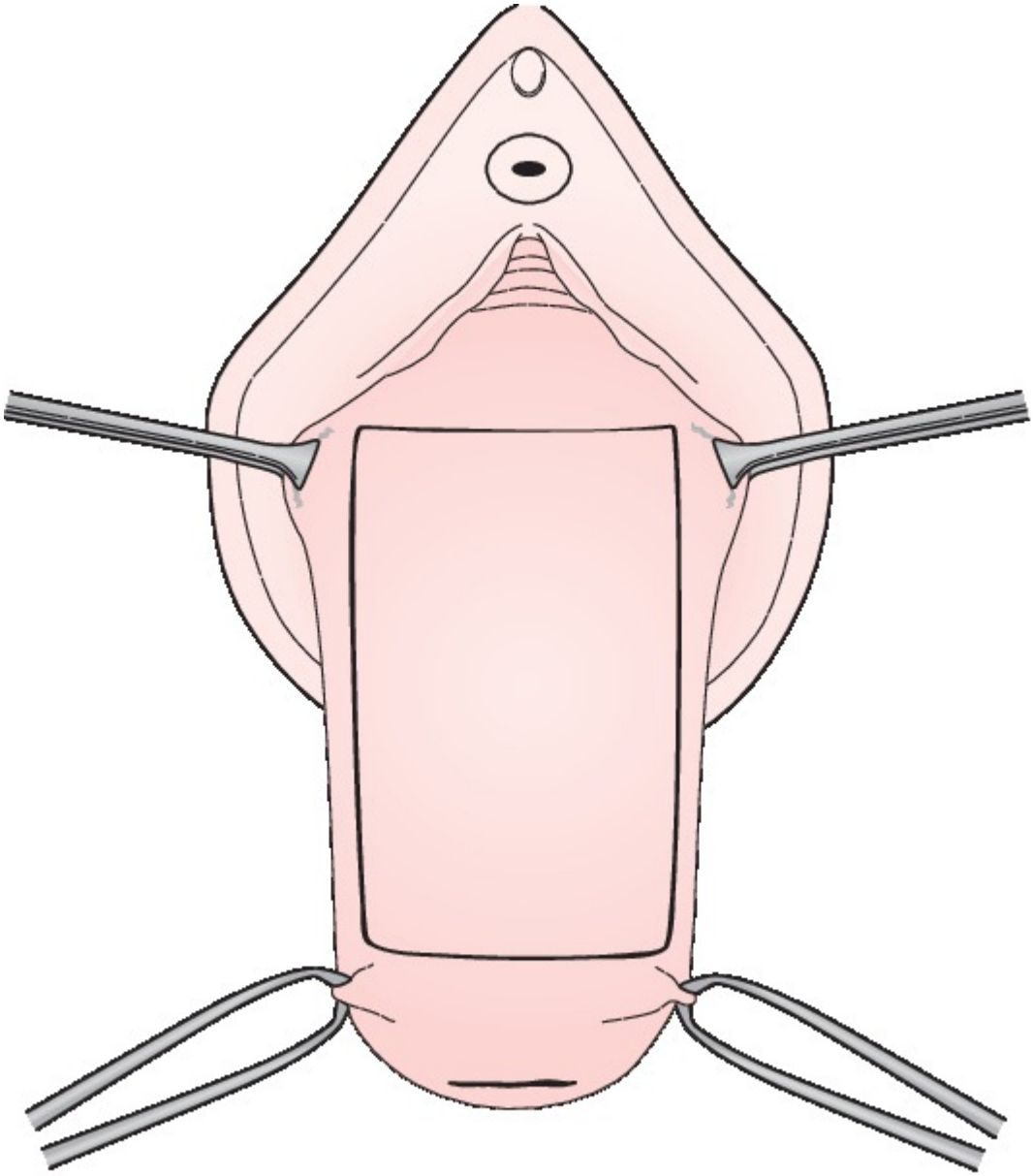
## CONSIDERATION FOR CONCOMITANT HYSTERECTOMY

Most surgeons do not favor performing a routine concomitant hysterectomy at the time of Le Fort colpocleisis. Gynecologic malignances following colpocleisis are rare, and the reduction of cancer risk is outweighed by additional perioperative risks. Concomitant hysterectomy has been associated with an increased risk of complications (including major blood loss requiring transfusion, bowel or bladder injury, and deep venous thrombosis), longer operative time and hospital length of stay, and increased risk of conversion to laparotomy. Furthermore, hysterectomy is not associated with greater improvement in objective vaginal support, in patient-reported, or in subjective rates of success. A recent decision analysis supported the recommendation for uterine conservation at the time of colpocleisis among patients over the age of 40. For patients with a known uterine source of postmenopausal bleeding, or with a history of cervical dysplasia, the consideration for a concomitant hysterectomy or alternative surgical approach should be strongly considered.

## LE FORT COLPOCLEISIS

First described by Leon Le Fort in 1877, the Le Fort partial colpocleisis is historically used in the setting of severe uterovaginal prolapse and is completed leaving the uterus *in situ*. The procedure is initiated by placing a Foley catheter to both drain the bladder and to aid in the delineation of the bladder neck. The cervix is then grasped with a tenaculum and placed on traction to evert the vagina. A marking pen or electrosurgical instrument is used to delineate the areas that are to be de-epithelialized both anteriorly and posteriorly

(**FIG. 34.1**). Anteriorly, a rectangle of vaginal epithelium should be marked from ~2 cm distal to the cervix to the level of the bladder neck. Slight traction on the Foley catheter will aid in identification of the bladder neck, which should lie ~4 cm from the external urethral meatus. A mirror image (or as close to a mirror image as possible) on the posterior vaginal wall should then be similarly delineated. It is critical that these rectangles be selected such that there is sufficient room proximally for the cervix (eg, after suturing the proximal edges to each other). In addition, a channel should be left on either side of the vagina, with a diameter that is sufficient to allow drainage of blood and cervical secretions but small enough that the cervix cannot prolapse through the channel. A channel of ~1 cm diameter will be created if a strip of 3 cm of vaginal epithelium is left intact bilaterally.



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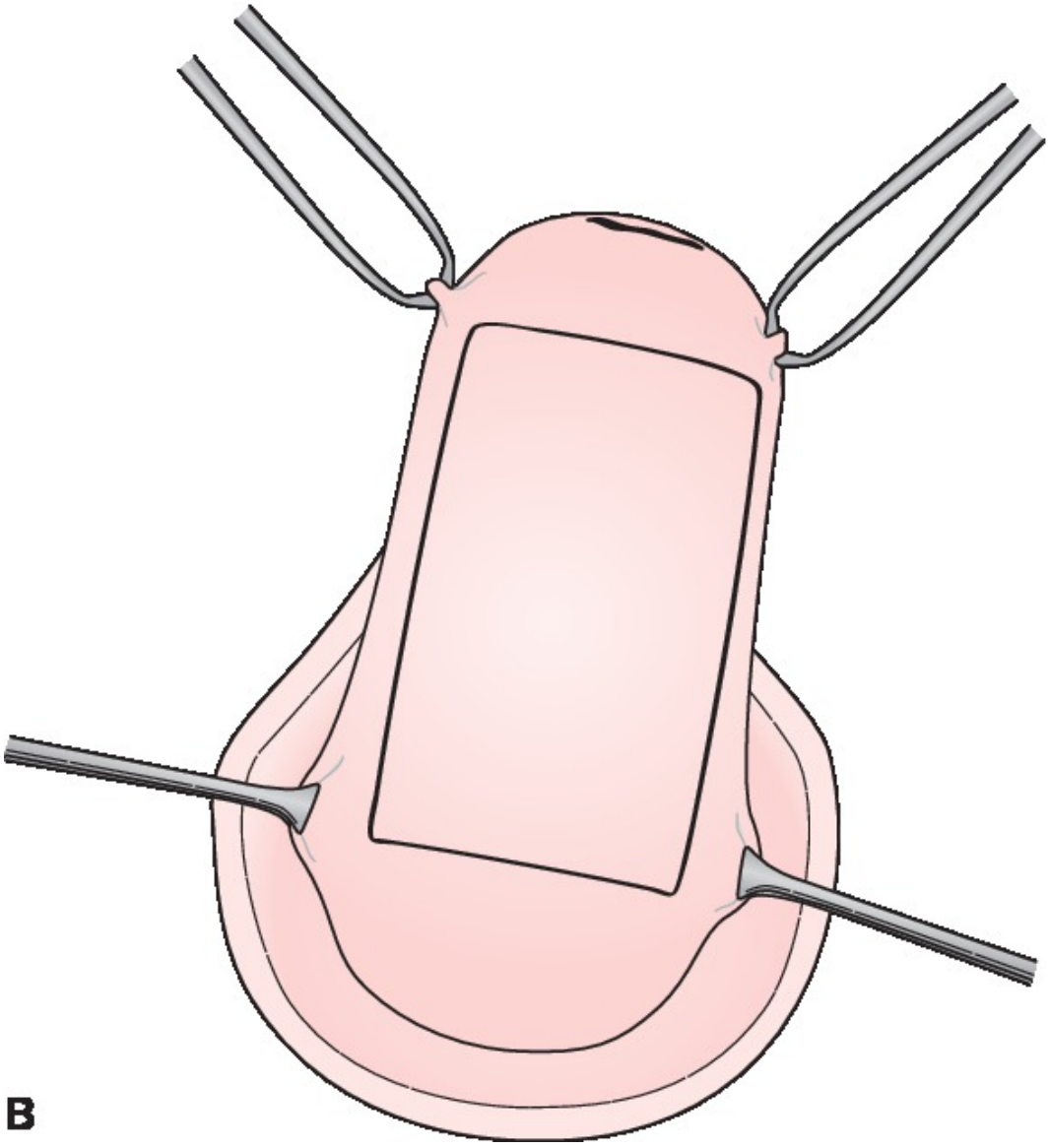



**FIGURE 34.1** Rectangles of vaginal mucosa are marked on the **(A)** anterior vagina and **(B)** posterior vagina. Laterally, a 3 cm gap is left between the rectangles to allow for the creation of drainage channels. (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and Pelvic*

*Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

The previously outlined areas are injected with 1% lidocaine with epinephrine or a dilute solution of vasopressin (such as 20 units in 30 mL sterile saline). The marked segments of vaginal epithelium are then removed by sharp dissection (**FIG. 34.2**). The surgeon should leave the maximum amount of fibromuscular vaginal wall behind, and care should be taken to avoid rectal injury or entry into the peritoneum. A finger in the rectum may be utilized to facilitate dissection or to assure rectal integrity. If the peritoneum is entered, the defect may be closed with delayed absorbable sutures in an interrupted fashion and the surgery continued. Hemostasis is vital for the prevention of hematomas and assurance of adequate healing and approximation of tissues. Following the removal of epithelium, a monopolar electrosurgical device or small interrupted sutures may be used to achieve hemostasis.

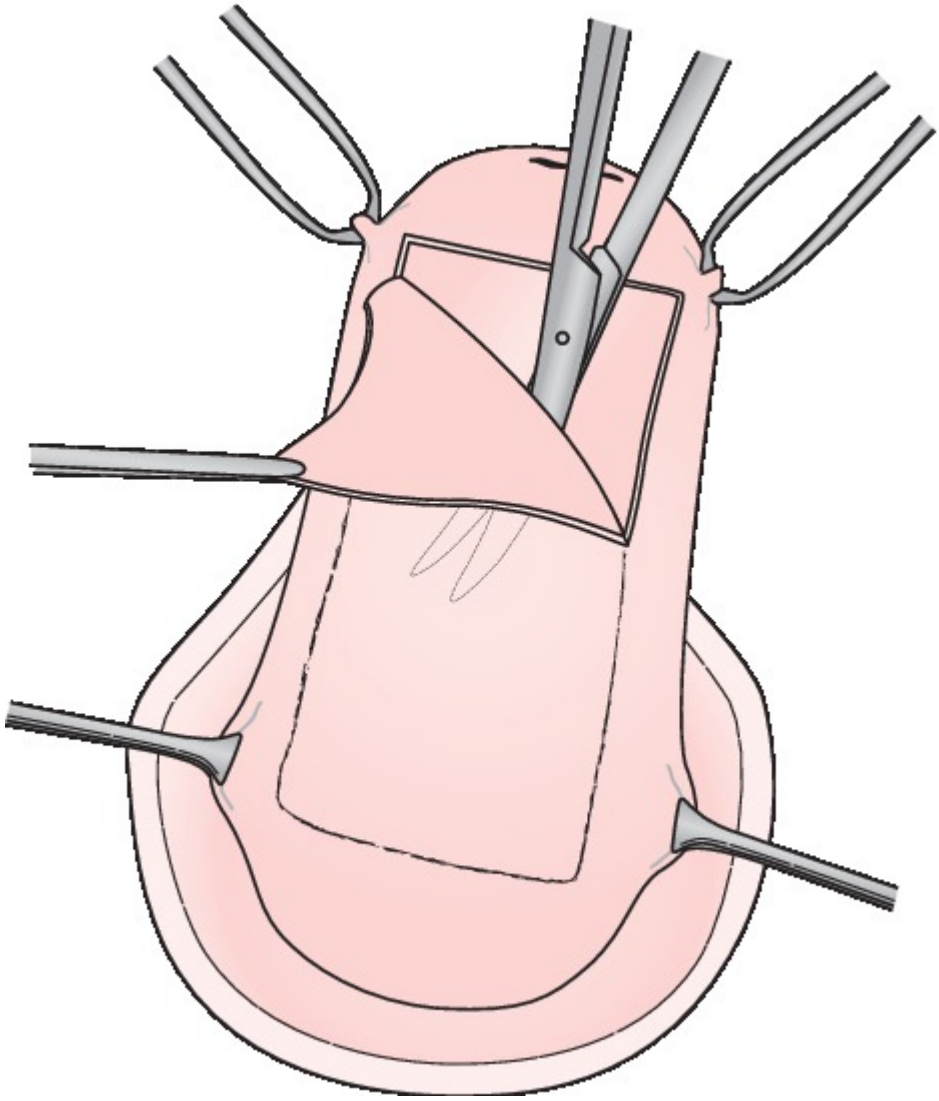
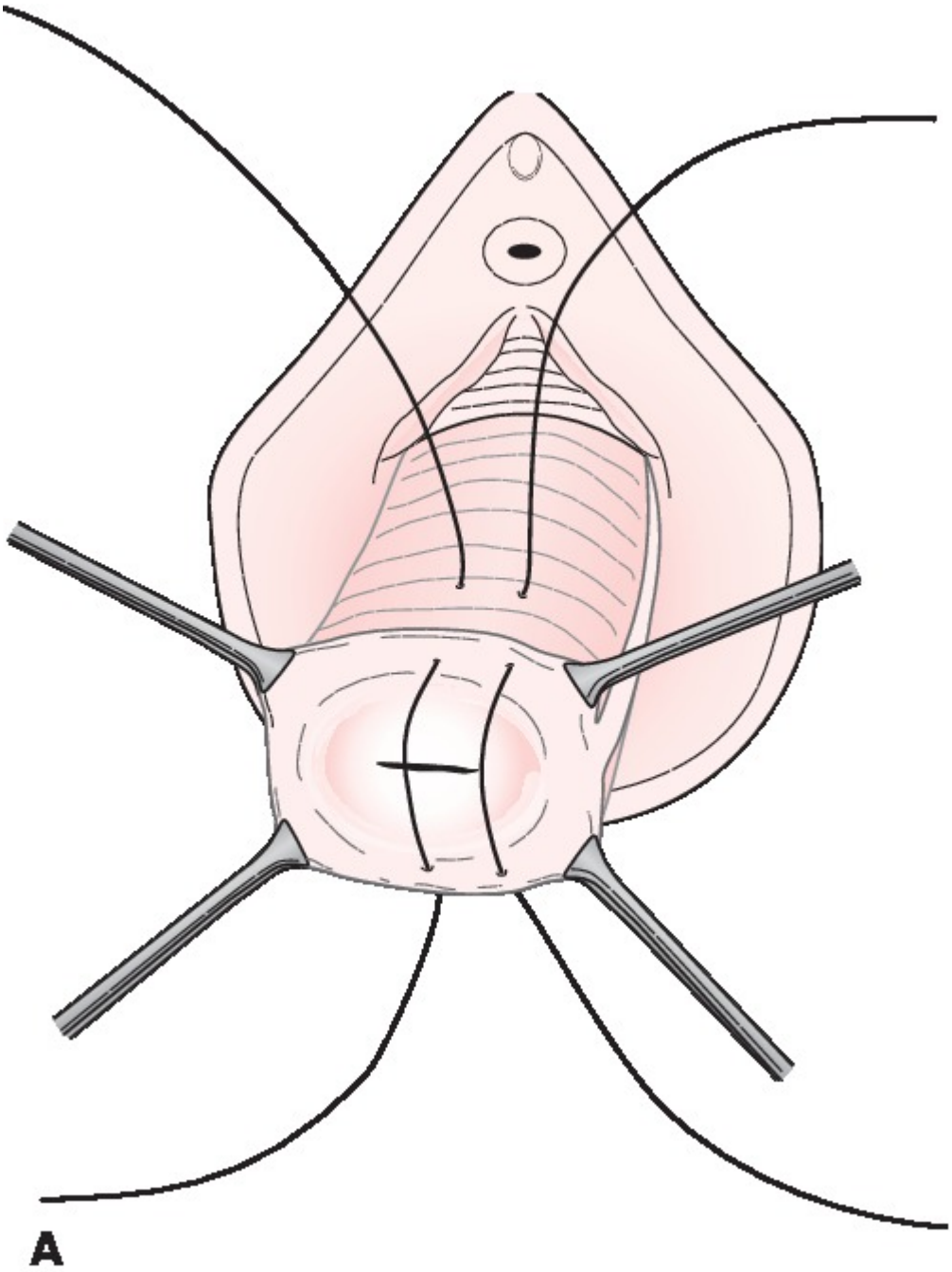


**FIGURE 34.2** The vaginal epithelium is removed. (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and Pelvic Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

The de-epithelialized areas of the anterior and posterior vaginal wall are then sewn together with successive rows of interrupted delayed absorbable sutures, beginning proximally (**FIG. 34.3**). With each row,

the lateral suture is placed such that the knot is turned into the epithelium-lined tunnels that were created bilaterally. As successive rows of sutures are placed and tied, the uterus and vaginal apex are gradually turned inward (**FIG. 34.4**). After the vagina has been inverted, the distal margins of the rectangle can be sutured to reapproximate the vaginal epithelium.



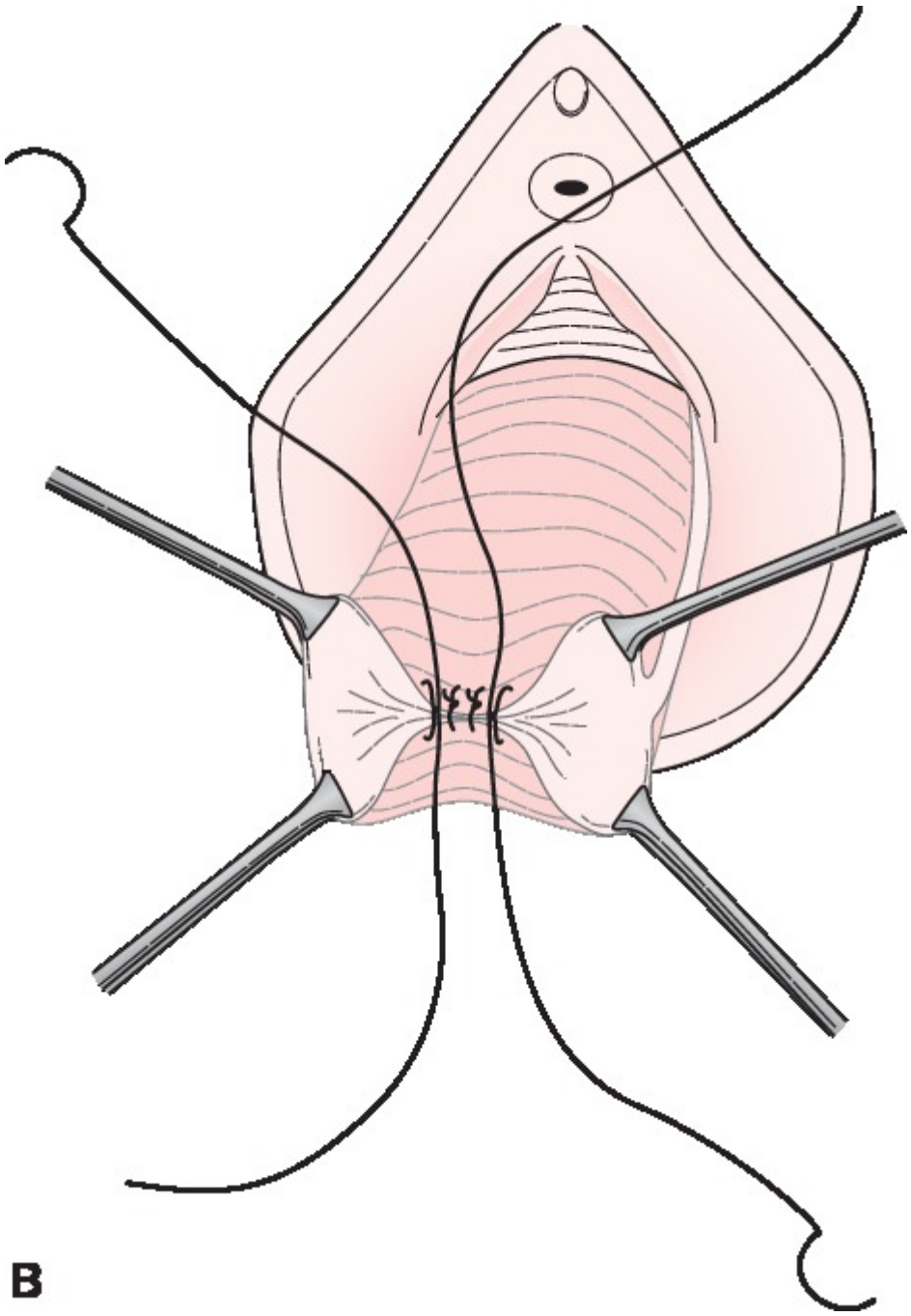



**FIGURE 34.3** The colpocleisis is closed in rows. **A.** The first row of interrupted delayed absorbable sutures is placed along the proximal edge of the dissection. **B.** As sutures are tied down, the excised rectangles are

brought together. (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and Pelvic Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

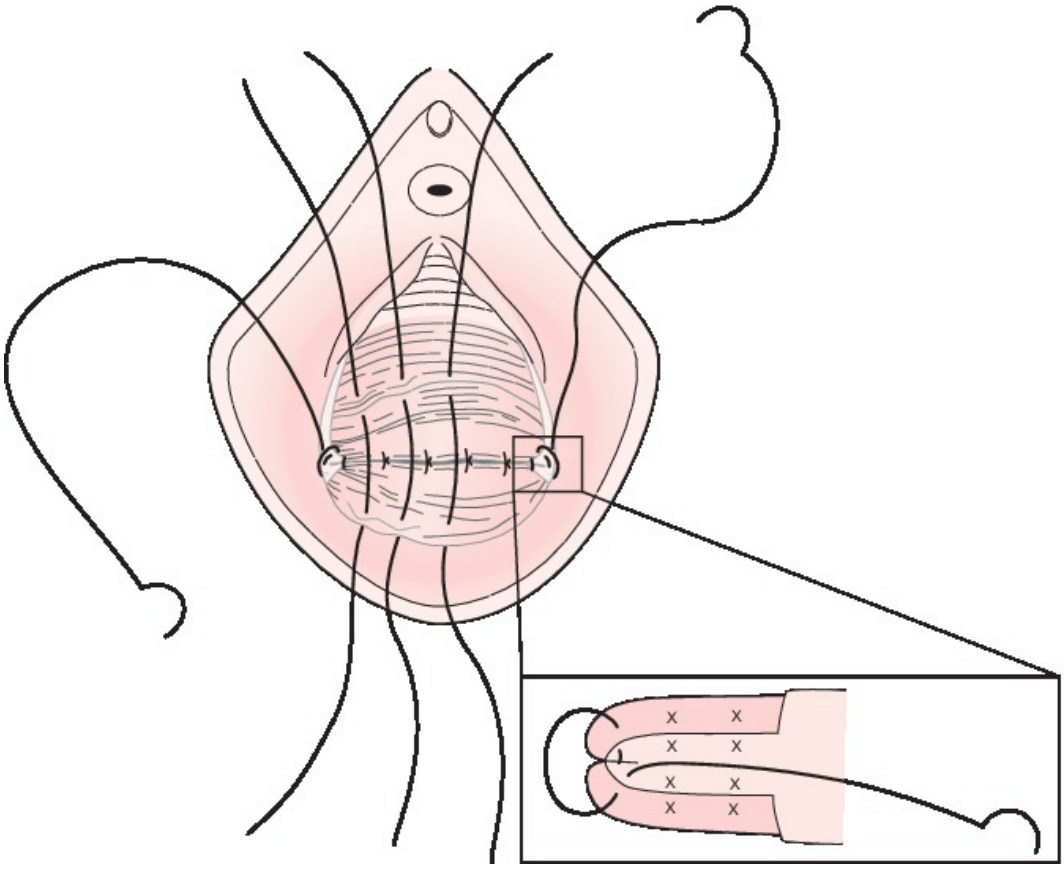


**FIGURE 34.4** Delayed absorbable sutures are placed in rows to reapproximate the vaginal muscularis. As each row is placed, the vagina gradually inverts. Laterally, the vaginal drainage channels are preserved. (Reprinted with permission from Bent AE, Cundiff GW, Swift SE. *Ostergard's Urogynecology and*

*Pelvic Floor Dysfunction*. 6th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007.)

The procedure is often followed by a distal levator myorrhaphy and perineorrhaphy (as described later) and an anti-incontinence procedure if indicated (**BOX 34.1**).

## BOX 34.1 STEPS IN THE PROCEDURE

### Le Fort Colpocleisis

- The patient is positioned in high lithotomy position.
- A Foley catheter is placed and the bladder drained.
- The cervix is grasped, and symmetric rectangles are marked on the anterior and posterior vagina. The proximal edge of each rectangle should typically be 2 cm distal to the cervix (to allow room for the cervix once the walls are approximated). The distal edge of the anterior rectangle is at the bladder neck, with a corresponding location selected posteriorly. Lateral channels should be left.
- The rectangular areas are injected with 1% lidocaine with epinephrine or a dilute solution of vasopressin, and the epithelium is removed by sharp dissection.
- The edges of the rectangle and denuded vaginal wall are closed in successive rows, using delayed absorbable interrupted sutures. The knots of the lateral sutures are turned into the epithelium-lined tunnels.
- As successive rows of sutures are placed and tied, proceeding from proximal to distal vagina, the uterus and vaginal apex are gradually turned inward.

- The vaginal epithelium is approximated with a delayed absorbable suture.
- Cystoscopy is performed to evaluate ureteral patency and to exclude lower urinary tract injury.

# COLPECTOMY/COLPOCLEISIS

For patients with posthysterectomy vault prolapse who do not desire vaginal penetrative intercourse, colpectomy/colpocleisis may be a favorable surgical management strategy. The distinction between this approach and a Le Fort colpocleisis is that the former technique does not require the creation of lateral drainage channels. Thus, the entire vaginal epithelium is removed (**FIG. 34.5**). It is our practice to limit the dissection to the vaginal segment superior to the bladder neck. This allows for future suburethral access if needed for the correction of stress urinary incontinence either concomitantly or through a staged procedure. We also recommend marking the vagina into quadrants to aid in the systematic infiltration of 1% lidocaine with epinephrine or a dilute solution of vasopressin and excision of the vaginal epithelium from the underlying endopelvic fibromuscular vaginal wall. As with the Le Fort procedure, the surgeon should leave the maximum amount of fibromuscular vaginal wall behind and care should be taken to avoid rectal injury or entry into the peritoneum. Similarly, hemostasis is vital.

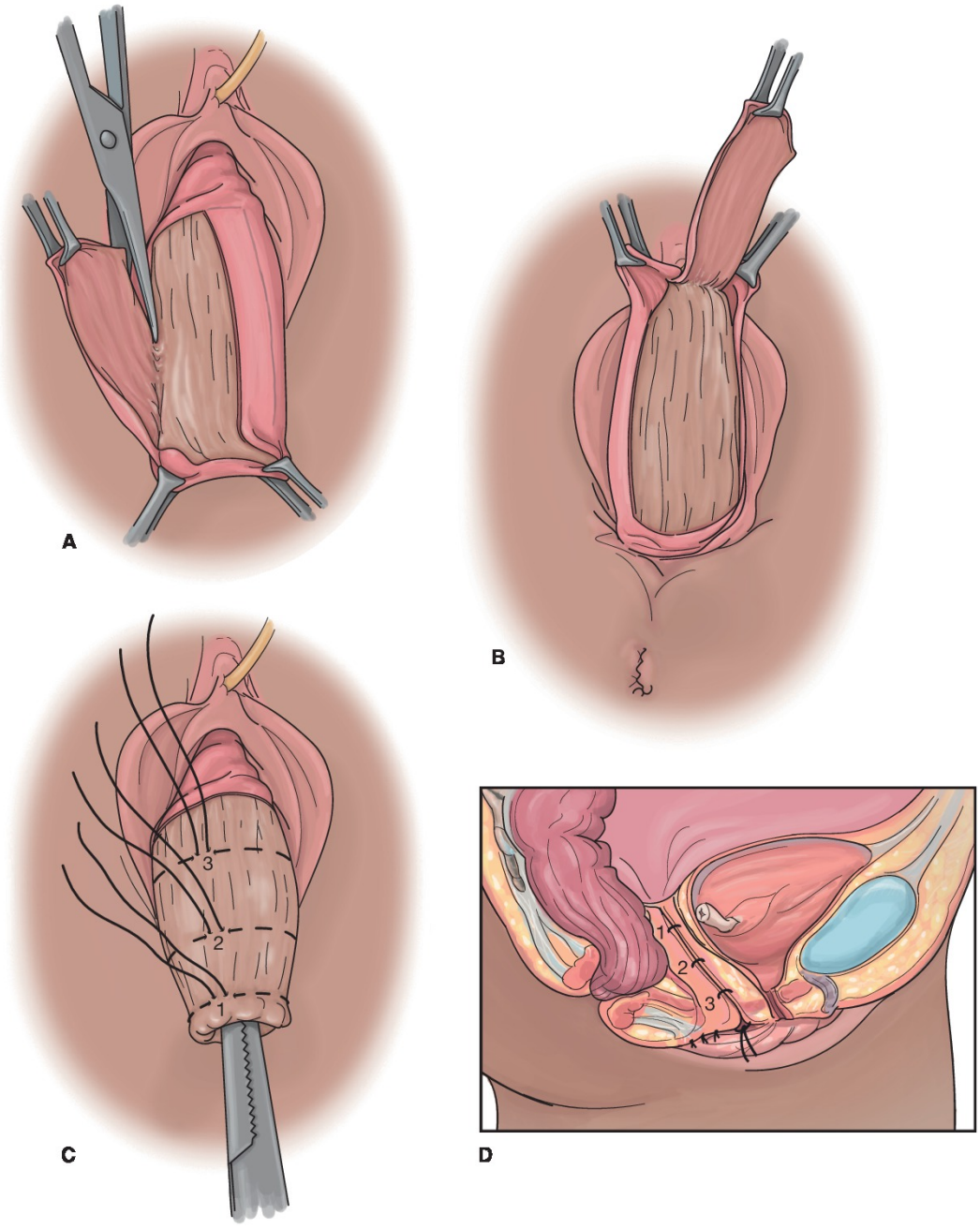



**FIGURE 34.5** Colpectomy and complete colpocleisis. **A, B.** After subcutaneous infiltration with lidocaine or bupivacaine hydrochloride in 1/200 000 epinephrine solution, the vagina is circumscribed by an

incision at the site of the hymen and marked into quadrants. Each quadrant is removed by sharp dissection. **C.** Purse-string delayed absorbable sutures are placed. The leading edge of the soft tissue is inverted by the tip of forceps. Purse-string sutures are tied *1* before *2* and *2* before *3*, with progressive inversion of the soft tissue before the tying of each suture. **D.** The final relationship is shown in cross section. A perineorrhaphy is also usually performed.

Following the excision of vaginal epithelium, a series of purse-string sutures are placed using delayed absorbable sutures. The sutures are tied in successive order from proximal to distal vagina, inverting the vagina gradually with each tie used to reduce the prolapse (**FIG. 34.5**). Forceps may be used to aid in the inversion of soft tissue prior to the tying of each suture. After the vagina has been inverted, the vaginal epithelial edges at the distal margin of the circumferential incision can be approximated.

As with the Le Fort procedure, the colpocleisis is often followed by a distal levator myorrhaphy and perineorrhaphy (as described later) and an anti-incontinence procedure if indicated (**BOX 34.2**).

## BOX 34.2 STEPS IN THE PROCEDURE

### Colpectomy/Colpocleisis

- The patient is positioned in high lithotomy position.
- A Foley catheter is placed and the bladder drained.

- The vaginal apex is grasped, the distal vagina is marked circumferentially superior to the level of the bladder neck, and the vagina is divided into quadrants.
- The subcutaneous tissue of the vagina is injected with 1% lidocaine with epinephrine or a dilute solution of vasopressin, and the epithelium of each quadrant is removed by sharp dissection.
- A series of purse-string sutures are placed, using delayed absorbable sutures.
- The sutures are placed and tied in successive order from proximal to distal vagina, inverting the vagina gradually with each tie.
- The vaginal epithelium is approximated with a delayed absorbable suture.
- Cystoscopy is performed to evaluate ureteral patency and to exclude lower urinary tract injury.

## CONCOMITANT LEVATOR MYORRHAPHY AND PERINEORRHAPHY

Following completion of the colpocleisis, a levator myorrhaphy and perineorrhaphy is typically performed (**FIG. 34.6**). The addition of this procedure greatly reduces the genital hiatus and provides perineal support to the obliterated vagina.

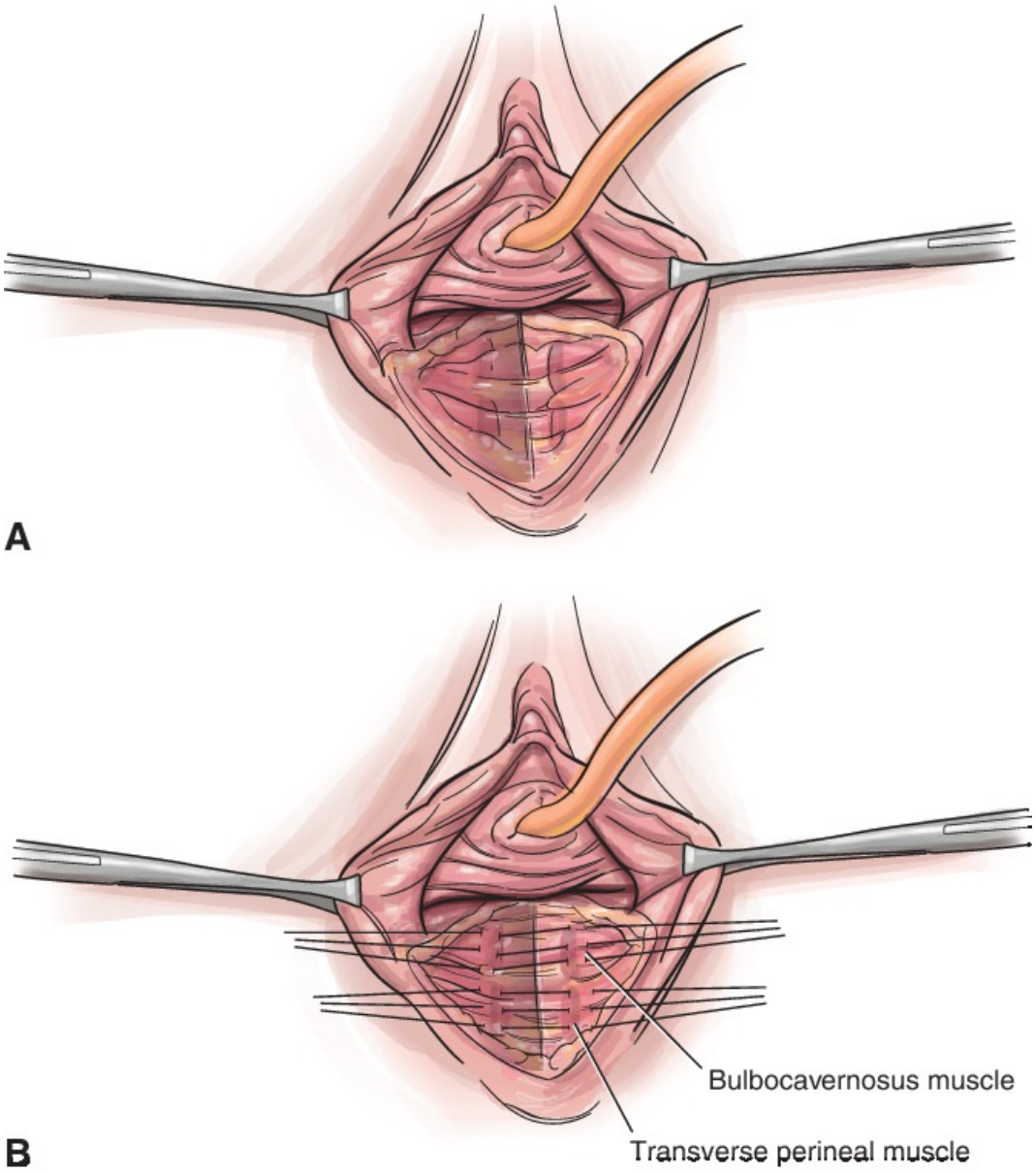



**FIGURE 34.6** Levator myorrhaphy and perineorrhaphy. **A.** A diamond-shaped area is sharply removed. **B.** Delayed absorbable sutures approximate the perineal muscles and connective tissues.

The procedure is initiated by demarcation of the surgical repair. This involves placement of two Allis clamps laterally on the vaginal introitus, typically at 4 and 8 o'clock. The Allis clamps may then be approximated to visualize the size of the expected postsurgical genital hiatus. While an aggressive reduction is ideal, care should be taken to not obstruct the urethra. A third Allis is then placed midline on the distal posterior vaginal wall, proximal to the last row of obliterative sutures. A fourth Allis is placed midline on the perineum.

The resulting diamond is outlined with a marking pen or electrosurgical device and the area injected with 1% lidocaine with epinephrine or dilute solution vasopressin (the authors recommend 20 units of vasopressin in 30 mL of sterile saline). The outlined vaginal epithelium is removed with sharp dissection, with care taken to leave behind the maximum amount of fibromuscular tissue and avoid rectal injury. If needed, a finger may be placed in the rectum during dissection to assure integrity. As with the colpectomy procedure, hemostasis of the de-epithelialized area is vital and may be assured using a monopolar electrosurgical device. The lateral edges of the remaining vaginal epithelium are mobilized laterally until the medial aspect of the puborectalis muscles is identified. Using two to three interrupted delayed absorbable sutures (the authors recommend polydioxanone or polyglactin), the muscles are plicated across the midline.

Perineorrhaphy is then initiated by identifying the components of the perineal body: the bulbocavernosus muscles, superficial and deep transverse perineal muscles. Interrupted delayed absorbable sutures are used to reapproximate the bulbocavernosus and transverse perineal muscles at the midline and recreate the perineal body. Although not often encountered, if necessary, the external anal sphincter may be incorporated into the repair.

Following the perineorrhaphy, the vaginal and perineal incisions are closed using a delayed absorbable suture in a running fashion. A transition in the plane of repair should be completed at the level of the posterior introitus to maintain proper alignment of sutures. The authors recommend a deeper running suture to the inferior aspect of the perineal incision, followed by a subcuticular closure ventrally to the vaginal opening. This technique allows for suture completion

inside the vagina, avoiding knot placement on the perineal body (**BOX 34.3**).

## BOX 34.3 STEPS IN THE PROCEDURE

### Levator Myorrhaphy and Perineorrhaphy

- Following completion of the colpocleisis, two Allis clamps are placed at ~4 and 8 o'clock on the introitus, such that approximation of the clamps results in significant reduction of the genital hiatus.
- A third Allis clamp is placed on the distal vaginal wall, and a fourth is placed midline on the perineal body.
- The resulting diamond-shaped area is injected with either 1% lidocaine with epinephrine or dilute vasopressin, and the epithelium is sharply removed.
- The posterior vaginal wall is mobilized laterally to expose the medial aspect of the puborectalis muscles.
- The levator ani muscles are plicated in the midline using delayed absorbable sutures.
- Separate delayed absorbable sutures are used to reconstruct the perineal body with care to approximate the bulbocavernosus and transverse perineal muscles.
- The vaginal and perineal skin is approximated with delayed absorbable sutures in a running fashion.

# PERIOPERATIVE AND POSTOPERATIVE CONSIDERATIONS

## Complications

Similar to most urogynecologic surgeries, perioperative complications following vaginal obliterative surgery are rare. The

most commonly reported complication is postoperative urinary tract infection, occurring in approximately a third of cases and accounting for 80% of reportable events in one large retrospective study. Major intraoperative adverse events including vascular or organ injury and hemorrhage are exceedingly rare, <2%. Of note, a prospective cohort study did find a significantly increased intraoperative blood loss during colpectomy/colpocleisis compared to Le Fort partial colpocleisis, highlighting the need for stringent hemostasis during the excision of vaginal mucosa. The risk of experiencing a major cardiac, pulmonary, or venous thromboembolic event is <1%, and such events are often associated with preexisting comorbidities. Adverse events including postoperative infections, return to the operating room, or admission to the ICU are also uncommon and appear to be lowest in higher volume centers. Overall mortality is estimated to be 1 in 400, even among the very elderly.

Given the anatomical characteristics of vaginal obliterative surgeries, these procedures are associated with a few rare but unique long-term risks. In the Le Fort procedure where the uterus is left *in situ*, cervical and uterine drainage is dependent upon the functional lateral tunnels. In the event of inadequate drainage, either from occluded channels or from a stenotic cervix, pyometra can occur weeks to months after surgery. This complication is rare but often results in the need for a hysterectomy. Last, while previously discussed as a rare occurrence, Le Fort colpocleisis may prevent timely diagnosis of future cervical or uterine pathology. Thus, a subsequent malignancy may theoretically be diagnosed at a more advanced stage.

The postoperative development of rectal prolapse has also been noted in the literature. This process is thought to be due to the unmasking of “occult rectal prolapse” in which the rectum previously prolapsed into the vagina along the trajectory of least resistance. When it occurs, rectal prolapse may be a debilitating condition requiring additional surgical repair.

## Intraoperative Cystoscopy

Following the completion of surgery, the authors recommend routine cystoscopy. Given its anatomical location in the setting of advanced prolapse, it is possible to obstruct the ureter with placement of the imbricating or purse-string sutures. Occurring in ~2% of surgeries, the obstruction is typically remedied by removal of the inciting stitch. Other bladder injuries are exceedingly rare. In one large study among 325 patients, only two bladder injuries were diagnosed and both were related to trocar perforation at the time of concomitant sling procedure. Despite the low prevalence of ureteral or bladder injury, intraoperative diagnosis is paramount to appropriate and timely management.

# Success/Failure Rates

Success rates for reduction of vaginal prolapse based on numerous case series are excellent, ranging from 91% to 100%. Additionally, incomplete bladder emptying and obstructive bowel symptoms typically improve following surgery. Overall satisfaction following surgery is high, around 90%. In a recent large case series of 325 women followed for 45 weeks (range 2-392 weeks) after Le Fort colpocleisis, 93% reported being “cured” or “greatly improved” and 98% were noted to have anatomical success defined as prolapse stage 1 or less. Significant improvement was noted in preoperative bowel symptoms (including constipation, obstructed defecation, and fecal incontinence), as well as voiding dysfunction and urinary retention. A second large series suggested a high rate of objective success, with 73% of patients demonstrating stage 0-1 support 12 months after surgery. Body mass index, medical comorbidities, prior hysterectomy or prolapse surgery, and preoperative POP-Q scores do not appear to impact the likelihood of success. However, two studies have noted the association between an increased duration of prolapse symptoms prior to surgical repair as well as postoperative vaginal length and genital hiatus with an increased risk of recurrence.

# Regret/Sexual Function

With appropriate preoperative counseling, regret following vaginal obliterative surgery is low, ranging from 2% to 9%, and is typically associated with prolapse recurrence or bothersome urinary symptoms. Few patients in the literature report any regret regarding their loss of coital function, and most would still elect to undergo the surgery again. In one study, 85% of women reported being satisfied with their sexual function following colpocleisis, regardless of whether or not they engaged in any sexual activity. While concerns regarding body image and the psychological effects of altered vaginal anatomy have been expressed, a recent study noted a significant improvement in body image scores at 24 weeks postoperatively. Furthermore, intercouple dialogue regarding sexual dysfunction, due to either the obliterative surgery or the partner's own limitations, can foster improved communication and the establishment of a "new sexual normal." On average, over 90% of patients who undergo colpocleisis would recommend the surgery to others.

# KEY POINTS

- Colpocleisis is an effective procedure for the treatment of pelvic organ prolapse among patients who do not wish to engage in vaginal penetrative intercourse.
- Perioperative risks are low with serious adverse events uncommon.
- Vaginal hysterectomy at the time of colpocleisis does not improve outcomes and may increase complication risks.
- Intraoperative hemostasis during the excision of vaginal mucosa is vital.
- Levator myorrhaphy and perineorrhaphy are recommended to provide perineal support and help prevent recurrent prolapse.
- Concomitant midurethral sling placement may be performed for appropriate patients and is associated with low rates of postoperative voiding dysfunction despite preoperative postvoid residual volumes.

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# CHAPTER 35

# VESICOVAGINAL AND RECTOVAGINAL FISTULA

Chi Chiung Grace Chen and Jaime Bashore Long

**Etiology and Epidemiology**
Obstetric Lower Reproductive Tract Fistulas
Nonobstetric Lower Reproductive Tract Fistulas
**Clinical Presentation**
Vesicovaginal Fistula
Rectovaginal Fistula
**Diagnosis and Evaluation**
Vesicovaginal Fistula
Rectovaginal Fistula
**Nonsurgical and Conservative Surgical Management**
Conservative Treatment of Vesicovaginal Fistula
Conservative Treatment of Rectovaginal Fistula
**Surgical Management**
Perioperative Considerations
General Principles of Fistula Repair
Surgical Approach to Repair of Vesicovaginal Fistula
Surgical Repair of Rectovaginal Fistula
Tissue Interposition

A fistula is an abnormal communication that forms between two epithelialized surfaces following injury or inflammation. Fistulas of the lower reproductive tract (uterus, cervix, and vagina) may develop with neighboring organs including the lower urinary tract (bladder, urethra, and pelvic ureters) and gastrointestinal tract (rectum, colon, and small bowel) or to external surfaces including the perineum and labia (**TABLE 35.1**). Lower reproductive tract fistulas form because of abnormal healing following childbirth, surgery, malignancy, radiation, or inflammatory diseases. The subset of lower reproductive fistulas managed by gynecologists includes vesicovaginal fistulas (VVF), urethrovaginal fistulas, vesicouterine fistulas, and rectovaginal fistulas (RVF). The management of other fistulas, including those involving the ureters or colon, may be beyond the scope of gynecologic practice and are not reviewed in this chapter.

## TABLE 35.1
## Anatomic Classification of Lower Reproductive Tract Fistula

| TYPE OF FISTULA | VISCERA[a] | COMMENTS |
|---|---|---|
| Vesicovaginal | Bladder and vagina | |
| Urethrovaginal | Urethra and vagina | May result from suburethral sling placement or urethral diverticulectomy |
| Vesicouterine | Bladder and uterus | Youssef syndrome, may result following cesarean section |
| Vesicocervical | Bladder and cervix | May develop after cervical cerclage |
| Ureterovaginal | Ureter and vagina | |
| Ureterouterine | Ureter and uterus | |
| Anoperineal (fistula-in-ano) | Anal canal and perineal skin | May result from abscess from an obstructed anal gland |
| Anovaginal | Anal canal (below the dentate line, within the first 3 cm of the anal verge) and vagina | External anal sphincter involvement common |
| Rectovaginal | Cephalad to the dentate line | |
| Colovaginal | Above the rectum | At the level of the cervix or vaginal cuff; more common posthysterectomy |
| Enterovaginal | Small bowel and vagina | |

[a]Combination fistulas can exist involving any of the above viscera.

It is likely that women have suffered from lower reproductive tract fistulas throughout human existence, most notably as a consequence of childbirth. Findings of VVF have been identified in mummified remains from ancient Egypt. From an anthropomorphic perspective, humans experience difficult birthing primarily due to the evolution of a relatively large fetal head in the setting of a relatively narrow pelvis, a consequence of bipedal biomechanics. Since the mid-19th century, the evolution of surgical management of urogenital fistulas (as described by Marion Sims, Thomas Emmet, Howard Kelly, and others) has had a lasting influence on the development of our specialty. However, lower reproductive tract fistulas remain a source of distress for patients and a challenging clinical situation for surgeons.

Although the published literature regarding lower reproductive tract fistula is extensive, it remains dominated by retrospective case series and expert opinion, with few randomized controlled trials. It is, therefore, necessary to consider the information presented in this chapter in the context of these limitations.

# ETIOLOGY AND EPIDEMIOLOGY

Pelvic fistulas may result from childbirth, pelvic surgery, malignancy, irradiation, infection, and inflammation. This section will separate etiologies into obstetric and nonobstetric for both VVF and RVF.

## Obstetric Lower Reproductive Tract Fistulas

In prolonged and obstructed labor, the presenting fetal vertex compresses the vaginal walls against the pubic symphysis. If this pressure is present for a sufficient period of time, this may lead to vascular compromise; subsequent epithelial necrosis of the intervening vaginal walls may occur. In such cases, the affected vaginal, bladder, urethral, ureteral, and/or rectal walls undergo necrosis and sloughing, thus creating the abnormal (often large) communication between adjoining viscera.

In lower resource settings, the most common cause of VVF traditionally is prolonged, obstructed childbirth, which in most series accounts for over 80% of fistulas in these regions. These circumstances have become exceedingly rare in higher resource countries owing to improvements in access to and delivery of skilled obstetric care. The conditions that lead to fistula formation may also result in vaginal scarring and stenosis, cervical laceration and destruction, sacral nerve damage (potentially affecting mobility), and ureteral injury (leading to hydronephrosis and renal damage). The World Health Organization (WHO) estimates that there are more than 1 million cases of untreated obstetric fistula in sub-Saharan Africa and Asia with 30 000-130 000 new cases developing annually. In these regions of the world, the incidence is estimated at over 120 cases per 100 000 births. However, the accuracies of these estimates are unclear as they are based mainly on extrapolation of hospital-based studies, expert opinions, or population-based surveys without confirmatory examinations.

Although the risk factors for fistula development are incompletely understood, commonly agreed-upon risk factors for obstetric fistula development include short stature, young maternal age (young age at marriage and subsequent pregnancy and delivery), and lower education and socioeconomic status. The factors that contribute most to the development of obstetric fistula are those that limit access to high quality, readily available obstetrical care. These fistulas still exist in lower resource settings due to limitations in the health care systems to provide timely access to family planning, quality maternal care (including skilled care at birth), emergency obstetric care, and fistula treatment.

Fistulas may also result from unrecognized injury to the bladder at the time of cesarean section. This may occur in both lower and higher resource settings and may be especially problematic in patients who are undergoing cesarean delivery for obstructed labor. Evidence suggests that VVF in lower resource settings are increasingly iatrogenic. For example, a recent study suggested that iatrogenic obstetrical fistula have increased in Pakistan from 43.2% in 2006-2008 to 71.4% in 2017-2018. Patients who develop obstetrical fistula after cesarean birth are also at risk to develop

fistulas that involve the lower urinary tract and uterus (ureterouterine, vesicouterine). Such fistulas may present either with the usual continuous urinary incontinence or with the triad of urinary continence, amenorrhea, or cyclic hematuria/menouria (Youssef syndrome) depending on the functionality of the endometrium and the cervix's ability to retain urine inside the uterus.

VVF have also been reported as a rare complication of obstetric procedures such as operative vaginal delivery and cervical cerclage placed for the treatment of cervical insufficiency. A 2012 case series and pooled analysis suggests that previous cervical procedures (prior cerclage or cervical conization), prior cesarean delivery, and use of the McDonald technique (which does not involve a bladder dissection as with the Shirodkar technique) may also play a role in the formation of urogenital fistula in these cases.

RVF most commonly result from obstetric trauma in both higher and lower resource settings. In lower resource settings, RVF are the result of obstructed labor and unrepaired severe perineal lacerations, whereas in higher resource settings, these fistulas typically occur either after unrecognized severe perineal injury or from infection and wound breakdown of laceration repair. In the United States, the overall incidence of RVF following vaginal delivery is 0.1%. Approximately 5% of fourth-degree perineal lacerations repaired at the time of delivery will result in infection and dehiscence with a smaller percentage progressing to RVF. Risk factors for severe perineal lacerations (extending through the anal sphincter complex) include primiparity, midline episiotomy, larger fetal size, older maternal age, use of operative vaginal delivery, and prior history of RVF. A large database study from a tertiary care institution found that over an 11-year period (1996-2006), the rate of severe perineal lacerations has declined, from 5.4% in 1996 to 1.3% in 2006. The age-adjusted rate of RVF repair in the United States has also declined in recent decades (3.0 per 100 000 in 1979 to 2.0 per 100 000 patients in 2006), paralleling the declining rate of episiotomies and operative vaginal delivery.

# Nonobstetric Lower Reproductive Tract Fistulas

Nonobstetric pelvic fistulas have been reported as a consequence of gynecologic, urologic, and general surgical procedures. The most common cause of urogenital fistulas in higher resource settings is pelvic surgery, specifically hysterectomy (80%-83%), followed by operative obstetric procedures (eg, cesarean section, forceps delivery, 8%-10%), other pelvic surgery (5%), and radiation (3%-5%). The overall incidence of urogenital tract fistulas after hysterectomy is 1.0 per 1000 (range 0.8 per 1000 to 3.0 per 1000). Higher incidences are associated with the laparoscopic/robotic approach as well as radical hysterectomy. Other causes of pelvic fistula include cancer, pelvic radiation, and chronic inflammatory conditions such as inflammatory bowel disease. While it is clear that social determinants of health play a pivotal role in the development and treatment of obstetric fistula, less is known regarding whether these factors play a significant role in the development of nonobstetric pelvic fistulas.

Nonobstetric pelvic fistulas are typically associated with abnormal healing in the setting of visceral wall injury and vascular and microvascular compromise. Animal models of fistulas reveal histologic changes including inflammation, fibrosis, foreign-body giant cell reaction, and recanalization of thrombus. Localized impaired healing may then allow for the formation of an epithelialized tract between two adjacent organs. This may be the mechanism for the development of fistulas after viscus injury incurred sharply or with electrocautery at the time of pelvic surgery. Microvascular compromise may also contribute to fistulas that develop following radiation, local infection, as well as conditions that may result in subacute infection or chronic inflammation such as inflammatory bowel disease. Implanted foreign materials, such as permanent mesh or suture, may further increase the risk for fistula development.

It is important to note that injury to a viscus with or without vascular compromise does not always result in fistula formation. Consider the vesicocutaneous tract that initially results from removal of an indwelling suprapubic catheter, which heals without further

intervention. The dependent area of the bladder may be more prone to fistula formation due to its closer proximity to the vagina and possibly due to the near-constant presence of urine in the dependent part of the bladder. However, experimental evidence has demonstrated that not all injuries in the dependent area of the bladder result in VVF formation. For example, in animal models of hysterectomy, fistula formation did *not* occur when figure-of-8 absorbable sutures were placed incorporating full-thickness bladder wall and vaginal cuff, nor when bipolar cautery was used to injure the bladder base. Fistula formation, however, was noted after a monopolar cautery–induced bladder base laceration. It should be noted that these findings may not be generalizable to humans undergoing hysterectomy because of anatomic differences. Although there are no comparable studies in the RVF literature, it is clear that the mechanisms involved in the development of nonobstetric fistulas are more complex than the previously assumed “undiagnosed viscus injury” or “inadvertently placed suture” and further research into the pathophysiology is needed.

Although far less common, RVF may also occur following difficult rectal or gynecologic surgery such as hysterectomy, hemorrhoidectomy, local excision of rectal tumors, and low anterior rectal resection, particularly when the posterior cul-de-sac is obliterated. For example, surgical management of deeply invasive endometriosis of the rectosigmoid has been associated with high rates of postoperative RVF (10%). The risk for RVF development is also increased in the setting of sigmoid diverticulitis and *prior* hysterectomy. A Swedish population-based cohort study demonstrated a hazard ratio of 4.0 (95% CI, 3.5, 4.7), 7.6 (95% CI, 4.8, 12.1), and 25.2 (95% CI, 15.5, 41.2), for RVF surgical intervention in the setting of hysterectomy only, diverticulitis without hysterectomy, and hysterectomy with diverticulitis, respectively, compared with patients who had neither previous hysterectomy nor diverticulitis.

In the absence of concomitant hysterectomy or implanted foreign materials, such as permanent mesh, the risk of VVF and RVF after reconstructive pelvic surgery is thought to be quite low; most of the literature addressing these complications associated with

urogynecologic procedures consists of case reports. Rare causes of fistulas include neglected vaginal pessaries, injection of urethral bulking agents, myomectomy, uterine artery embolization, loop excision of the cervical transformation zone for cervical intraepithelial neoplasia, and voluntary interruption of pregnancy.

Pelvic malignancies (including tumors of the urinary system, anal canal, rectum, and gynecologic organs) and radiation therapy used to treat these cancers can result in immediate or delayed pelvic fistula formation. Pelvic fistulas that present early during radiation therapy are more likely to be caused by necrosis of the tumor, whereas fistulas that occur later are caused by radiation injury to the tissue. When fistulas occur remote from the initial cancer treatment, recurrent cancer should be suspected. Fistulas following radiation usually occur within 2 years and are thought to occur because of obliterative endarteritis, which leads to impaired tissue perfusion, ischemic necrosis, and tissue sloughing. This impaired vascularity and loss of tissue planes complicate attempts to repair these types of fistula. Inflammatory bowel disease, such as ulcerative colitis or Crohn disease, is another important cause of RVF. After obstetric injury, Crohn disease is the second most common cause of RVF; patients with Crohn disease have a reported 10%-35% risk of developing an RVF.

# CLINICAL PRESENTATION

## Vesicovaginal Fistula

The classic presentation of urogenital tract fistula is continuous urinary leakage or watery discharge from the vagina several days or weeks following pelvic surgery (gynecologic, urologic, or general surgery) or obstetric trauma/obstructed labor. This may occur in the absence of urinary urgency, Valsalva maneuvers, or changes in body position. Other potential causes of postoperative urinary leakage should also be considered (**TABLE 35.2**). Any patients with complaints of urinary leakage from the vagina should raise suspicion of a lower urinary tract injury and undergo further investigation including a thorough pelvic examination. The degree to which

leakage presents depends primarily on the location and size of the fistula and the condition of the surrounding tissues. Patients may have a spectrum of leakage from truly continuous to intermittent (primarily at bladder capacity or with certain body positions). For example, patients with vesicouterine fistula may have various symptoms including continuous or intermittent urinary leakage. Some may also present with a triad of symptoms including urinary continence, amenorrhea, and cyclic hematuria (Youssef syndrome).

## TABLE 35.2
## Differential Diagnosis of Postoperative Urinary Incontinence

- Persistent/recurrent fistula
- Unrecognized fistula (additional fistula(s) not recognized at the time of fistula repair)
- Stress incontinence
- Urge incontinence
- Mixed incontinence
- Overflow incontinence
- Vaginal discharge/erosion of mesh

Patients with VVF, especially those caused by obstructed labor, may also present with pelvic pain, dyspareunia, and irregular vaginal bleeding due to the extent of local ischemia and subsequent tissue damage. Patients may develop bladder stones from dehydration, urinary stasis, foreign bodies, and urinary infection. Any significant urine leakage, even for a short period of time, may result in significant irritation of the vagina, the skin of the vulva, or the perineum. In one series of obstetric fistula patients, dermatitis symptoms were noted in 20% of patients. Prolonged continuous urinary leakage may also lead to phosphate crystallization precipitating on the vagina and vulva, further irritating the area. As expected, patients with fistula, both iatrogenic and obstetric,

experience overall decreased quality of life with many of these individuals experiencing depression and other psychological sequelae.

## Rectovaginal Fistula

Occasionally, RVF may develop immediately following obstetric trauma. More commonly, these fistulas appear 7-10 days after delivery. Dehiscence of a primary repair, inadequate repair, or infection at the primary site may explain this delayed presentation.

Patients suffering from RVF most commonly report varying degrees of uncontrollable passage of gas or feces from the vagina. A malodorous vaginal discharge and insensible fecal soiling of the undergarments are also common complaints. These symptoms may be more pronounced when bowel movements are loose. In RVF of obstetric etiology, nearly half of patients have concomitant fecal incontinence because of the frequent compromise of the sphincter mechanism inherent in this complex perineal trauma. Other symptoms suggestive of RVF include dyspareunia, perianal pain, vaginal irritation, and recurrent genitourinary tract infections. Patients' symptoms are typically reflective of the location, size, and etiology of the RVF. Occasionally, a small fistula may be asymptomatic.

# DIAGNOSIS AND EVALUATION

There have been several pelvic fistula classification systems devised in hopes of providing a prognostic indicator prior to intervention. Thus far, there is no commonly agreed-upon classification system for any lower reproductive tract fistulas. Importantly, the prognostic ability of these classification systems has been noted to be fair to poor for repair success with some evidence suggesting better prognostic ability for postrepair urinary incontinence. Instead of arbitrarily using various classification systems, the authors recommend describing the fistula in detail (**TABLE 35.1**) with specific emphasis on the location of the fistula relative to bladder or rectal landmarks.

# Vesicovaginal Fistula

The diagnosis of nonobstetric VVF is usually straight-forward; however, it may occasionally be more elusive. In all cases, it is essential to carefully assess the condition of the surrounding tissue (eg, indurated, edematous, necrotic, scarred, fibrotic, etc.) and degree of epithelialization (eg, presence of granulation tissue, etc.). Other critical features are the number and size (diameter) of the fistula and the location relative to bladder landmarks (eg, ureter/interureteric ridge, trigone, urethra/bladder neck, etc.). It is also important to assess the condition of the vagina and location of fistula relative to vaginal landmarks (eg, introitus, cuff/cervix, etc.). Additionally, it is helpful to consider the accessibility of the fistula for vaginal repair. In the instance of a recurrent fistula, knowledge of prior conservative management and review of the surgical description of prior repair attempts may be helpful for choosing the most appropriate route, type, and timing of the repair.

Pelvic examination is typically undertaken in the dorsal lithotomy position, although at times jackknife prone, genupectoral, or left lateral positions may be needed to best visualize the fistula. The external genitalia including the perineum and vulva are inspected for abnormalities including, but not limited to, scarring, erythema, irritation, breakdown, and encrustation from constant exposure to urine. These findings are important as the condition of this area may affect surgical planning especially if perineal/vulvar flaps are being considered. The entire speculum can be used to look for pooling of urine, especially if the fistula is located at/near the vaginal apex or cervix. In some cases, a watery vaginal discharge may lead to a suspicion of fistula; if the source of the fluid is not clear, the fluid can be collected and creatinine level determined. Other causes of increased vaginal secretion include vaginitis, fallopian tube cancer, and peritoneal or lymphatic fistula.

Use of a Sims speculum or a split speculum can further aid in assessing the vagina. If there is puckering of tissue and a fistula tract is not clearly seen, use of a thin probe (eg, lacrimal duct dilator, cervical os finder, etc.) may be helpful. It is important to carefully evaluate all areas of vaginal rugation, redundancy, or puckering,

even if a fistula is already identified as there may be multiple fistulas, which may involve different organs. For example, in one series of 14 928 patients with obstetric fistula in Ethiopia, 13.2% of women had both a VVF and an RVF. A biopsy to evaluate for tumor recurrence may be needed if there is a history of pelvic malignancy.

Bimanual examination of the vagina is performed to evaluate for characteristics that may influence surgical planning such as vaginal length; appearance of vaginal tissue including inflammation, infection, or atrophy; and presence of vaginal stricture or vaginal or pelvic masses. In patients with a suspicious history in whom a urogenital tract fistula is not visualized, a “tampon test” can be performed. Although the sensitivities and specificities of this and other similar tests discussed below are unknown, instillation of colored water or saline (eg, methylene blue, blue food dye) into the bladder typically stains a vaginal swab or tampon blue in the presence of a bladder fistula (eg, vesicovaginal, vesicocervical, vesicouterine). False-positive results may occur from leakage from the external urethral meatus. To reduce the possibility of a false-positive test, a transurethral Foley catheter can be used to occlude the external urethral meatus. Vaginal swabs that are unstained but wet may indicate a ureteral fistula. In this case, further evaluation for suspected ureterovaginal fistula can include a second phase in which either oral phenazopyridine (stain orange) or intravenous methylene blue (stain blue) is administered with vaginal swab or tampon to evaluate for ureteral fistula (eg, ureterovaginal, ureterocervical, ureterouterine, etc.). Patients with VVF should still be evaluated for ureteral involvement, as in one series up to 12% of patients with a bladder fistula also had a ureteral compromise.

On rare occasions, if these office procedures are not diagnostic despite a compelling history, the patient is asked to take oral phenazopyridine and wear a series of tampons at home over a longer period of time with varying degrees of physical activity. The tampons are placed individually in plastic bags and brought in to be inspected. The patient must be counseled regarding careful use of the tampons to eliminate the possibility of dye contamination during insertion or removal.

Although preoperative cystourethroscopy is not always required prior to VVF repair, it may be helpful to better delineate the size and number of fistula and the location within the bladder and proximity to the ureters, trigone, and bladder neck. Furthermore, any additional abnormalities within the bladder such as induration, edema, scarring, ureteral patency, stone, and foreign material can be noted. If distension with normal saline or water is not possible during cystourethroscopy due to the size of fistula, a Foley catheter can be placed within the fistula tract or packing in the vagina to facilitate bladder distension. Bladder biopsy can be performed if there is a lesion suspicious for malignancy or infectious agents such as tuberculosis. When there is clinical suspicion of a vesicouterine fistula, hysteroscopy may be helpful in making the diagnosis.

Some have advocated urodynamic testing prior to repair of a VVF. Although limited studies have suggested that concomitant autologous fascial sling placed at the time of fistula repair does not result in increased fistula repair failures or other complications including the need for sling removal, the decision to proceed with concomitant surgery for stress incontinence should be individualized (eg, in the case of urethrovaginal fistula) and not dependent on preoperative urodynamic findings.

Evaluation for ureteral compromise may include computed tomography (CT) urography, intravenous pyelogram/retrograde pyelogram, or voiding cystogram. These imaging modalities can be used to evaluate the kidney and ureters. The retrograde pyelogram may be especially useful to evaluate the distal ureter if not well seen by other imaging modalities. Furthermore, imaging may be needed to thoroughly delineate a complex fistula with multiple channels and openings. Magnetic resonance imaging (MRI) would typically be reserved for the setting in which a fistula is not identified by other imaging studies.

# Rectovaginal Fistula

Physical examination begins with inspection for stool soiling around the perineal area or stool/stool-like discharge in the vagina. Similar to VVF, the location, size, and number of fistula should be assessed

using a split speculum. Granulation or puckering of the tissue may provide clues to help identify RVF. Placing an examining finger in the rectum may also aid in the delineation of the fistula tract. The route of the fistula may be outlined by the passage of a thin probe from the vagina through the fistulous tract into the anal or rectal canal. Additionally, the location of RVF relative to landmarks in the rectum/anus (eg, anal sphincter, dentate line, etc.) and the condition of the remaining rectum/anus are important to note. Bimanual examination of the vagina is performed to assess for length, inflammation, masses, or stricture, which may influence surgical planning. It is also helpful to have the patient contract the puborectalis and external anal sphincter to assess for competency as multiple studies have demonstrated that concomitant sphincter injury is very common, particularly when obstetric trauma is the cause of the fistula. The perineal body should also be examined, with care to assess for inflammation of the surrounding tissues. Multiple perianal fistulas should raise suspicion of Crohn disease.

In patients with a history compatible with a fistula but in whom no RVF can be identified, several simple office tests have been described. With the patient in a slight Trendelenburg position or with elevation of the hips, a 20-Fr Foley catheter is placed in the anal canal. After the Foley balloon is distended up to 5 mL, air is instilled through the catheter while the water-filled or soap-covered vagina is observed for any escape of air bubbles originating from the anal canal. Likewise, a tampon test may be performed in which a tampon is placed in the vagina and the patient is given a small enema with blue-colored water or saline (eg, methylene blue, blue food dye, etc.). Discoloration of the tampon is noted in the presence of a fistula. However, this test may be negative if the fistula opening is in the very distal anal canal. In this case, dye can be mixed with lubricating gel and massaged along the anterior rectal wall to assess for a small or distal communication. Proctoscopy/proctosigmoidoscopy or an anorectal speculum may also be useful in visualizing the fistulous tract from the rectal side as well as assessing for any other mucosal abnormality. Simultaneous vaginoscopy has also been described to assist in colovaginal fistula localization by cannulating the tract with a guidewire from the vaginal

opening to the colonic side. This intervention can pinpoint the exact location of the tract to assist in surgical planning.

Before surgical repair of RVF, endoanal ultrasound should be considered. This study allows for objective assessment of the sphincter integrity, as well as the location of the fistula tract and any associated abscess or tract extensions, which is critical in surgical planning. Additionally, with techniques such as three-dimensional ultrasound (with or without placement of hydrogen peroxide in the suspected fistula tract), the accuracy is improved. Many low RVF, particularly those of obstetric etiology, have anatomic relationship to the sphincter complex. Failure to recognize and repair sphincter injury or preserve sphincter integrity at the time of RVF repair may result in continued or new-onset fecal incontinence even if the RVF repair was successful.

Anal manometry is not as sensitive in identifying sphincter injuries but may have a role in evaluating the compliance of the rectum in RVF patients with IBD or previous radiation. If the anal sphincter or rectal reservoir is damaged, diminished sensation or control may result in continued loss of stool via the rectum rather than through the vagina. Furthermore, in cases of RVF related to radiation or Crohn disease, the rectum may remain noncompliant and, therefore, not function as a normal reservoir. The fecal incontinence experienced by these patients is not related to anal sphincter defects and, therefore, may not be amenable to surgical correction.

Radiographic studies may also be necessary to define sigmoidovaginal fistulas or fistulas associated with primary bowel disease. The cause of such high RVF is usually inflammatory, including diverticulitis and Crohn disease. Radiation injury, traumatic injury, and carcinoma are less common causes. Passage of fecal material or gas through the vagina in the absence of a rectal communication should lead one to suspect a fistula arising from the sigmoid colon or small intestine, as with a colovaginal or enterovaginal fistula. Vaginography with a water-soluble contrast medium can help to delineate high communications, particularly in posthysterectomy vaginal cuff RVF. A barium enema is not as sensitive in identifying these fistulas, owing to its thick consistency

and inability to generate sufficiently high pressure to identify a narrow tract, but may provide general information as to the overall health of the colon. A CT scan of the abdomen and pelvis using oral contrast may be helpful if it shows contrast in the vagina. Pelvic MRI has demonstrated usefulness as a diagnostic tool for RVF. MRI is regarded as one of the best imaging modalities for complicated RVF cases, particularly for perianal fistula. It allows for delineation of the fistula tract, as well as any associated extensions and abscesses.

# NONSURGICAL AND CONSERVATIVE SURGICAL MANAGEMENT OF LOWER REPRODUCTIVE TRACT FISTULA

Management of any type of pelvic fistula should include addressing the perineal and vulvar dermatitis that may have resulted from constant exposure to urine and/or stool. Topical ointments such as zinc oxide and dimethicone can be used to form a protective barrier to decrease epithelial irritation. Regardless of the ultimate treatment strategy, whether conservative management or more invasive surgery, optimal care of patients with pelvic fistula should include improving nutrition to enhance healing as well as optimizing existing medical conditions and encouraging smoking cessation. Additionally, vaginal estrogen, especially in postmenopausal patients, can be beneficial as an adjunct to conservative strategies or in the perioperative period.

## Conservative Treatment of Vesicovaginal Fistula

For patients with urogenital fistulas, symptoms may be minimized by placing a contraceptive diaphragm into the vagina. A Malecot catheter inserted into the center of the diaphragm (and connected to a urine collection bag) may be used to collect urine and divert it from

soiling the perineum/vulva. For ureteral fistulas that are not amenable to a trial of conservative treatment with ureteral stent placement as discussed below, interval placement of percutaneous nephrostomy tubes should be considered to decrease inflammation as preparation for surgical repair.

Some VVF may heal without surgical intervention. However, there is no consensus or definitive evidence on the fistula characteristics that are most amenable to these treatments or the duration of treatment. Conservative management was typically selected for bladder fistulas 5 mm or less, located supratrigonally, unrelated to malignancy, and with minimal evidence of epithelialization (fistulas that developed within 4-6 weeks of the initial injury).

The most conservative option is prolonged bladder drainage with a transurethral Foley catheter. In the above review, 16% of patients were initially managed with catheter drainage (duration 2-12 weeks); only 8% of these patients had resolution of their fistulas. In a large retrospective study of 1716 patients with obstetric VVF, continuous bladder drainage resulted in fistula closure in 15% of patients. Most patients had small fistulas and presented for care no more than 4-6 weeks after delivery. Typically, the transurethral catheter is left in place for 4-6 weeks, especially if it results in minimal/decreased drainage from the fistula (vagina).

Other minimally invasive treatment options for bladder fistula include curetting, electrofulguration, and laser ablation. The goal of these therapies is to de-epithelialize the fistula tract to promote healing (while the bladder is being continuously drained). Most of the studies reported success rates between 67% and 100%, but the limitations of these studies are the small number of patients observed and the focus on small fistulas (≤4-5 mm) in patients after gynecologic surgery or radiation. Others have reported adding various substances to enhance healing after the fistula tract has been de-epithelialized, including the introduction of fibrin glue, cyanoacrylic glue, and bovine collagen, as well as injection of autologous platelet-rich fibrin glue and plasma into the surrounding vaginal tissue. While the evidence associated with these conservative surgical options is promising, it remains sparse with

short follow-up periods. Despite these limitations, minimally invasive attempts at fistula closure should always be considered in a patient who has a small fistula and those who are poor surgical candidates.

For ureterovaginal fistula, ureteral stent placement for 4-12 weeks can be the initial treatment for ureteral fistula with evidence of ureteral patency. In one series of 19 patients who presented with ureteral fistula a median time of 19 days (range, 10-29 days) from the inciting surgery, ureteral stent placement was attempted and successfully placed in 11/12 patients. Ureteral stents were left in place for a median time of 73 days (range, 27-101 days), which resulted in successful resolution of ureteral fistula in 10 cases. Complications included ureteral stricture (*n* = 1, required ureteral preimplantation) and pyelonephritis (*n* = 2). Ureteral stenting was not attempted in 7 patients: 1 patient experienced spontaneous resolution without intervention and 6 patients underwent primary repair with ureteroneocystostomy (3 with concurrent VVF, 2 had ureteral injury recognized at time of index surgery with attempt at repair, 1 had a 1-year delay in diagnosis of the ureteral fistula). As expected, stent placement may be more successful if the ureteral fistula is diagnosed early: in another series, 82% of patients with ureteral fistula <1-month duration experienced successful closure with ureteral stent placement vs 33% of patients with older fistulas. After fistula closure and stent removal, radiologic imaging such as retrograde pyelogram or CT urogram should be done to evaluate for ureteral stenosis.

## Conservative Treatment of Rectovaginal Fistula

RVF after obstetric trauma may heal with conservative treatment, whereas those associated with cancer or radiation injury have little chance of healing without surgical intervention. Importantly, minimally symptomatic RVF may not require repair; some cases can be managed indefinitely with dietary modification and fiber supplementation for stool bulking, which reduces soiling through the fistula tract. A large multicenter retrospective review found a high

rate of healing achieved with conservative management (65%); however, only a small number of patients were selected for this modality. Many of these conservatively managed RVF (45%) were <0.5 cm in diameter. Conservative treatment modalities were variable but included daily sitz baths, a variety of oral antibiotics, wound debridement, and fiber supplementation to increase stool bulk. Other adjunctive therapies included topical estrogen and physical therapy. Another nonsurgical management option is placement of a seton, which is a foreign body (eg, permanent suture, vessel loop, etc.) that can be passed through the fistula tract. If the seton is left loose, the fistula tract will slowly mature and heal as well as allow for any existing abscess to drain; if tightened, the body will eventually expel the seton, thus creating a fistulotomy leading to closure of the fistula. Setons are mostly effective for fistula-in-ano, although resultant fecal incontinence can be an issue (due to disruption of the internal and/or external anal sphincters when the fistulotomy is created as the fistula heals). Studies suggest that the efficacy of seton use in RVF repair is disappointing, with successful healing as low as 5%.

Fibrin glue instillation in the fistula tract for both fistula-in-ano and RVF has also been studied with varying success rates (14%-63%). Clinical practice guidelines put forth by the American Society of Colon and Rectal Surgeons in 2016 concluded that fibrin glue is a relatively ineffective treatment; however, some experts have recommended it as an adjunct or overlay to traditional surgical repairs, but data on efficacy are limited. However, fibrin glue may be considered for patients at risk for surgical complications or fecal incontinence, as this procedure has minimal associated pain or other untoward outcomes.

Placement of a bioprosthetic plug in the RVF tract is another minimally invasive option. These anal plugs are typically cylindrical, consisting of cellular collagen matrix, such as those derived from porcine small intestine submucosa, and have been described for repair of both anovaginal and RVF. First, the fistula tract is debrided, and then the plug is secured into the tract with sutures or buttons at both ends of the fistula opening. Excess plug length can be excised from both the rectal and the vaginal ends. The plug promotes an

inflammatory response, which is gradually replaced by scar tissue. There is concern that bioprosthetic plugs may be less successful in high anovaginal and RVF because these fistula tracts tend to be shorter (with less intervening tissue between the vagina and the anus/rectum). In a 2017 randomized controlled trial comparing collagen plug vs advancement flap in RVF not due to inflammatory bowel disease, the recurrence rate of RVF was higher in the plug arm (66%) compared with the advancement flap arm (38%). Although the success rates of plugs are modest, the benefit is that there is no compromise to continence (while in contrast there is a risk of sphincter compromise associated with setons or traditional surgical intervention) and minimal disruption of surrounding tissue planes during plug placement, allowing for potential repair in the future if the plug is unsuccessful.

Advancements in immunotherapy and biologic medications have made pharmacologic treatment the first step in the treatment of RVF associated with Crohn disease, particularly for low or perianal fistula. Antibiotics are initiated to address any pelvic or perianal sepsis. Immunomodulators and monoclonal antibodies (such as antitumor necrosis factor) augment the body's ability to spontaneously heal fistulas associated with Crohn disease; these include methotrexate, 6-mercaptopurine, cyclosporine, infliximab, and vedolizumab. Intralesional injection of mesenchymal stem cells into the vaginal wall of the RVF tract has also recently shown promise resulting in healing in 70%-80% of RVF associated with Crohn disease.

For higher-related RVF or colovaginal fistula, endoscopic therapy holds promise. Endoscopic techniques aim to identify the fistula tract, close the primary (feeding) side of the fistula with clips, and either fill the tract with fibrin glue/plug or keep the exit orifice open. It is of upmost importance to ensure closure of the primary opening precedes or accompanies closure of secondary (exit) opening. If closure of the secondary opening occurs prior to closure of the primary opening, the patient may develop abscess or sepsis.

# SURGICAL MANAGEMENT OF LOWER REPRODUCTIVE TRACT FISTULA

When conservative therapy fails or the patient is not a candidate for conservative therapy, surgical repair is the only alternative to relieve the patient of symptoms. When preparing patients for surgical correction, it is important to keep in mind that patients may have some degree of frustration and anxiety, especially if the etiology of their fistula is iatrogenic. All aspects of operative risk should be discussed with the patient prior to fistula repair, including the likelihood of failure or fistula recurrence. Even in the event of successful anatomic repair, the occurrence or persistence of lower urinary tract symptoms (such as incontinence, overactive bladder, voiding dysfunction, bladder pain), rectal symptoms (such as incontinence, defecatory urgency, rectal pain), and/or vaginal symptoms (such as dyspareunia) should be discussed. It is also important to present the expected recovery course; possible need for radiologic imaging and other future procedures including surgical; potential adverse consequences of associated procedures such as episiotomy or Schuchardt incisions, hysterectomies, and colostomies (in the case of RVF); disfigurement from flaps; and discomfort from intra-abdominal drains or ureteral stents and suprapubic or transurethral catheters (in the case of urogenital fistulas) during the healing process.

The pelvic surgeon must determine the optimal timing, technique, and route of repair, as well as determine what suturing technique to use, how many layers of closure are sufficient for repair, and whether an interposition graft is needed. It is also important to note that there is some evidence to support repair success is highest after the initial repair: a retrospective review of 2484 Nigerian patients with VVF (92.2% obstetric related) demonstrating a surgical cure rate of 81.2% for patients requiring only one surgery vs 65.0% for those requiring two or more surgeries; similar conclusions were also reached in the RVF literature, although most of these case series involved smaller

numbers. This finding coupled with the lack of definitive clinical trials guiding providers on the essential aspects of surgical repair led the authors to recommend that these types of surgeries be undertaken by specialists with specific training in this area. As such, the surgical principles presented below are intended as guidelines, and the exact management strategy should be individualized based on factors such as the patient's comorbidities, etiology of the fistula, and physical findings associated with the fistula.

# Perioperative Considerations

The American College of Obstetricians and Gynecologists 2018 Practice Bulletin recommends antibiotic prophylaxis for colporrhaphy and laparotomy, without specific recommendations regarding fistula surgery. Typically, one dose of prophylactic antibiotics is recommended with fistula repair. In the obstetric VVF literature, although antibiotic prophylaxis did not result in improved repair success in a placebo-controlled randomized trial of 79 patients, fewer patients who received antibiotics developed a urinary tract infection by postoperative day 10 (40% vs 90%, odds ratio 0.07 [95% CI, 0.01, 0.55]). Extended antibiotic prophylaxis (continued for 7 days after surgery) is not indicated.

In the RVF literature, there is evidence that a single dose of intraoperative, broad-spectrum intravenous antibiotics improves repair success rates following acute anal sphincter laceration repair. There is no evidence supporting the use of postoperative antibiotic prophylaxis. The authors recommend antibiotic prophylaxis administered at the time of surgery without the extended use of antibiotics, unless there is evidence of clinical infection at the time of surgical repair.

Specific to RVF repair, preoperative mechanical bowel preparation may be considered. On the morning of operation, some experts have recommended administering tap water enemas until there is passage of clear content from the rectum. However, recent colorectal literature does not support the use of bowel preparation before abdominal bowel surgery, calling this practice into question with RVF repair. The quality of evidence supporting this

recommendation, however, is low and should be interpreted with caution. Alternatively, the authors prefer to digitally remove rectal contents followed by irrigation of the rectum using a Malecot catheter in the operating room prior to antisepsis preparation of the operative field and subsequent repair. This practice is thought to reduce the fecal and bacterial load, reducing the risk of postoperative wound infection and dehiscence.

# General Principles of Fistula Repair (TABLE 35.3)

## TABLE 35.3
## Surgical Principles and Considerations of Lower Reproductive Tract Fistula Repair

| PRINCIPLE/CONSIDERATION[a] | COMMENTS |
|---|---|
| Preoperative evaluation | VVF: consider cystoscopy, radiologic imaging to determine location of fistula relative to urethra and ureter (and if ureters are involved)<br>RVF: consider endoanal ultrasound to determine involvement of anal sphincter |
| Timing | Early (≤72 h after injury) vs delayed (no definitive time period but usually ≤12 wk)<br>Timing is individualized: once tissue quality is optimized (based on periodic examinations) and infection, if present, is addressed and resolved |
| Repair attempts | Highest success with first attempt and decreased success with subsequent attempts |
| Antibiotics | Single dose administered perioperatively |
| Bowel prep (RVF) | No evidence supporting improved outcomes |
| Route | VVF: transvaginal or transabdominal (laparoscopic, robotic)<br>Most can be closed transvaginally except<br>Inadequate exposure<br>Need for bladder augmentation<br>Need for ureteral reimplantation<br>Need for additional abdominal procedure<br>RVF: transvaginal, transanal, or transabdominal (laparoscopic, robotic) surgical approach, consider<br>Status of the anal sphincter<br>Fistula location/accessibility<br>Etiology/complicating factors |
| Excision of fistula tract | Minimally trimming or no excision, unless there is fibrosis/scarring |
| Tension-free closure | Adequate mobilization of fistula and surrounding tissue |
| Watertight closure (VVF) | Retrograde fill the bladder after the first-layer closure to confirm watertight |
| Choice of suture | Delayed absorbable suture in an interrupted or continuous fashion |
| Layered closure | Two to three layers if possible |
| Tissue or vascular flap interposition | Vascular flap: Martius, rectus, gracilis, omentum, peritoneum, and sigmoid epiploica<br>Biologic graft: porcine small intestine submucosa, acellular porcine dermal graft Provides additional blood supply or tissue barrier and closes dead space |
| Postoperative bladder drainage (VVF) | 7-10 days of continuous bladder draining using transurethral catheter or suprapubic catheter |

[a]Surgical principles/considerations apply to all lower reproductive tract fistula unless otherwise noted.
VVF, vesicovaginal fistula; RVF, rectovaginal fistula.

One of the most essential surgical considerations is when to perform the fistula repair. Although there is no consensus or definitive evidence on the optimal timing of repair, most experts would consider a surgical repair within 72 hours of the initial injury, provided there is no significant inflammation in the underlying tissue and no contraindication to surgery. During this time, the tissue is usually still pliable, allowing for adequate dissection and tension-free closure. If early repair is not possible (eg, if the fistula or injury is not realized until days or weeks after the primary surgery), repair is traditionally delayed for several months to allow the surrounding tissue to heal adequately from the inciting injury. However, these recommendations were formulated primarily from experiences with obstetric fistulas, where the extent of ischemia may be wide with extensive involvement of the surrounding tissue. Several case series have shown the safety and efficacy of earlier repair (within days to a few weeks) if there is no evidence of concurrent infection, inflammation, or necrosis in the tissue bed. Furthermore, some studies have suggested that operative time and estimated blood loss are positively correlated with patient's age and time to surgery. In the 2017 systematic review and meta-analysis on management of VVF from benign gynecologic surgery, success was similar between surgery within 12 weeks of fistula occurrence and surgery more than 12 weeks after fistula development. This principle is also applicable to obstetric fistulas and fistulas from radiation injuries, although the wider extent of injury to the surrounding tissue may require a longer delay before surgical repair. For radiation-induced fistula found during or proximal to active radiotherapy, some experts have recommended waiting at least 12 months after completion of radiotherapy. Therefore, the timing of fistula repair should be individualized and based on physical examination of the surrounding tissue.

The above principle also pertains to RVF; however, as these types of fistulas may often be accompanied by local infection and

abscess formation, drainage of these collections (eg, with seton placement), local care (eg, sitz baths, wound care, debridement, and stool bulking to reduce perineal soiling, etc.), and oral antibiotics may be needed to optimize tissue health prior to definitive surgical treatment. Directed surgical intervention can be employed once the local infection/abscess has resolved and there is decreased inflammation of the surrounding tissue. In cases of obstetric anal sphincter injury dehiscence, small case series suggest that early revision is feasible, safe, and successful. For fistulas associated with inflammatory bowel disease, optimizing management of the underlying disease is essential to optimize the chances of having a successful repair. In addition, as discussed above, conservative approach alone may lead to spontaneous healing of the fistula.

Another important surgical principle is fistulotomy. In Sims' classic article describing the surgical treatment of bladder fistulas, he emphasized the need to excise all scar tissue within the fistula and create fresh tissue edges for reapproximation. This may be especially critical for obstetric fistulas due to the potentially wider extent of damage and subsequent fibrosis of the surrounding tissue. Disadvantages of excising the fistula tract include increasing the fistula size, thereby compromising the size of the residual bladder/rectum, as well as increasing the potential for bleeding requiring cauterization, which may affect healing. Despite these original tenets, there is currently no consensus about whether excising the margins of the fistula is necessary. In a randomized trial of 64 patients with obstetric VVFs who underwent vaginal repair with or without excision of fistula tract, the success rates were similar (75% not trimmed vs 68% trimmed). However, these findings may not be generalizable as the authors did not comment on the extent of local fibrosis and all the patients underwent vaginal fistula repair with Martius graft augmentation. There is no level I evidence specifically addressing this issue in the RVF literature. Therefore, the authors recommend not trimming or minimally refreshing bladder or rectal fistula edges in general, unless the fistula edges are fibrotic and unlikely to heal when reapproximated.

Additional surgical principles advocated by Sims and by present-day experts include widely mobilizing the bladder or rectum from the

surrounding tissue to create a tension-free closure of the fistula and atraumatic handling of tissues to preserve the vascular supply needed for subsequent wound healing, including the minimal use of electrocautery. Some experts have advocated for placing the sutures extramucosally, excluding the mucosal layer of the bladder or rectum. However, it may not be possible to avoid the mucosa in actual practice. Also, there is no definitive evidence to support the benefits of placing sutures extramucosally.

Absorbable suture is usually used, in part, to minimize any potential complications with permanent suture if it were to be placed through the mucosa (such as stone formation in the case of bladder fistula). There are also no trials comparing different suture types (monofilament or multifilament/braided, absorbable, or permanent) or calibers. The authors also recommend using fine-caliber suture, usually 3-0 or 4-0 suture (eg, polyglactin 910) on layer closest to the bladder or rectal mucosal, followed by larger-caliber suture of the same type (2-0 or 3-0) on the vesicovaginal fibromuscular connective tissue or the rectovaginal fibromuscular connective tissue and on the vaginal epithelium.

Although Sims also described a single-layer fistula closure and leaving the vagina epithelium open without any surgical reapproximation, most experts now advocate for multilayer closure, primarily to reduce the tension placed on the first layer of closure and to add extra layers of tissue between the bladder or the rectum and the vagina. A retrospective review of 832 bladder fistulas addressing one-layer vs two-layer closure showed similar success rates in both groups. Another one of the technical details most often debated is the use of interrupted or continuous closure technique with no clear consensus or evidence supporting one method over the other. The authors generally recommend the use of continuous suturing technique unless there is concern over the local perfusion of the tissue surrounding the fistula.

One of the most important surgical considerations is deciding on the route of repair: transabdominal or transvaginal for VVFs and transabdominal, transvaginal, or transrectal for RVF. To an increasing extent, abdominal repairs are also being performed laparoscopically with or without robotic assistance. Selecting the

optimal route of surgery must consider the accessibility of the fistula, the etiology of the fistula, the history of prior surgical repair(s), the expertise of the surgeon, and other contextual factors. For example, as many of these procedures are being performed in lower resource settings with patients under regional anesthesia, vaginal repairs may be better tolerated by patients under those conditions. Other important considerations include the need for concomitant procedures (eg, the need for ureteral reimplantation abdominally in the case of VVF or the need for fecal diversion abdominally or anal sphincter repair vaginally in the case of RVF). While a 2016 systematic review of VVF in both higher and lower resource settings found higher success rates for transvaginal compared with transabdominal repairs (90.8% vs 83.9%), none of the included studies were randomized controlled trials. Furthermore, as most case series of RVF repair outcomes have demonstrated similar success rates with transabdominal, transvaginal, or transrectal routes of repair and have included RVF of various etiologies and anatomic locations, it is not possible to draw definitive conclusions as to the optimal route of repair. Therefore, for both VVF and RVF, the transvaginal approach is typically preferred among gynecologic surgeons, if feasible, as this approach is associated with patient benefits including decreased recovery time, hospital stay, cost, and may be associated with an overall decrease in perioperative complications.

Another factor to consider prior to embarking on surgery is whether tissue interposition/flap is needed at the time of fistula repair. This option should be considered if the fistula is recurrent or refractory, if the surrounding tissue is extensively scarred with impaired vascularity, or if the fistula originates from causes such as obstructed labor, radiation, or previous infection. The rationale of using a flap is to increase vascularity to the repaired area by interposing healthy, well-vascularized tissue or to augment the repaired area and obliterate the potential dead space. Various vascular flaps have been described for both vaginal and abdominal approaches. These include gracilis muscle, labial fat pad/Martius, rectus abdominis muscle, omentum, peritoneum, and sigmoid epiploica. These are described in further detail later in the chapter. In

a 2017 systematic review and meta-analysis of VVF from benign gynecologic surgery, 51.3% of patients received repairs with graft interposition. Interposition of a variety of biologic materials such as fibrin has also been described.

# Surgical Approach to Repair of Vesicovaginal Fistula

## *Vaginal Approach to Repair of Vesicovaginal Fistula*

Most bladder fistulas can be repaired transvaginally, but examination under anesthesia may be needed to make this determination to confirm that the fistula is accessible vaginally. Schuchardt or episiotomy incision may be performed to facilitate access to the fistula. A Foley catheter (sizes range from 6 to 30 Fr) can be placed in the fistula tract and balloon inflated in the bladder. Gentle traction is placed on the catheter to improve access and exposure of the fistula and surrounding tissue to facilitate dissection. If the fistula tract is too small in diameter for the placement of a catheter through the tract, gentle dilation may be performed, or a small-caliber vascular catheter with an inflatable catheter balloon at the tip which ranges from 2 to 7 Fr, can be used (eg, Fogarty arterial embolectomy catheter [Edwards Lifesciences, Irvine, CA]). Some experts recommend injection of normal saline or a dilute hemostatic solution (eg, lidocaine with epinephrine, vasopressin) into the tissue surrounding the fistula to facilitate dissection and maintain local hemostasis. Placing stay sutures at four corners of the vaginal epithelium is key to outline the margins of the intended area of dissection.

Typically, simple, small fistulas near the vaginal apex (eg, posthysterectomy fistula) can be repaired using the Latzko technique, while larger, more complex fistulas (eg, fistula from obstructed labor) may require a more extensive dissection. In the Latzko technique of partial colpocleisis, the bladder is mobilized circumferentially from the surrounding tissue, but the fistula tract is

not excised, as it is imbricated into the bladder cavity with closure of the fistula (FIG. 35.1). Subsequent steps are performed as outlined in “Steps in the Procedure” section (BOX 35.1).

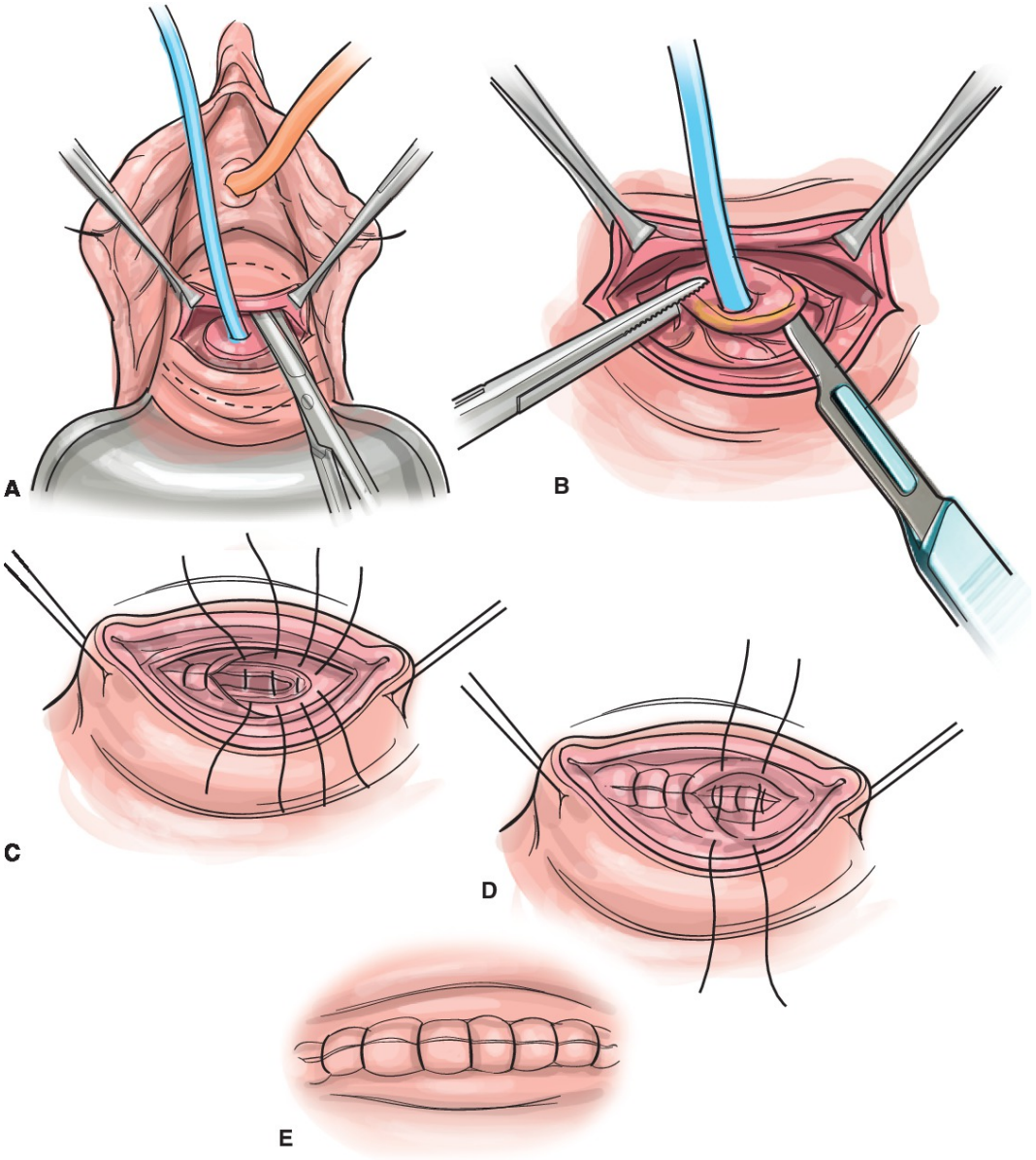



**FIGURE 35.1** Traditional vesicovaginal fistula repair. **A.** Initial incision of a circumferential collar around the fistulous opening. The vaginal epithelium is sharply dissected radially

from the collar. **B.** If there is fibrosis, the fistula tract may be excised sharply, making sure that healthy tissue is left to be reapproximated. Excessive trimming, increasing the loss of tissue, should be avoided. **C.** Interrupted or running suture is used to close the first layer. Sutures are placed ~0.5 cm apart with sufficient purchase of tissue to securely close the defect. **D.** The second layer imbricates over the first-layer closure with interrupted or running suture. **E.** The vaginal epithelium is closed after ensuring proper hemostasis in the vesicovaginal space.

## BOX 35.1 STEPS IN THE PROCEDURE

### Vesicovaginal Fistula Repair

- Evaluate fistula cystoscopically and vaginally to assess size, location relative to known landmarks (eg, urethra, trigone, ureters), and the quality of the injured tissue.
- Place ureteral stent(s) if the fistula is close to the ureter(s). Place transurethral Foley catheter if feasible.
- Access the fistula vaginally, intraperitoneally, and/or transvesically (see text for details). Care should be taken to avoid prolonged clamping of the surrounding tissue and avoid/minimize the use of electrocautery.
- Circumscribe the fistula and sharply mobilize the bladder from the vagina and other surrounding tissue to allow for tension-free closure, keeping ureteral location constantly in mind.

- Excise any area of severe fibrosis/scarring that may be involved in the fistula closure.
- Reassess the vesicovaginal dissection to ensure adequate separation of the bladder from the vagina for a tension-free repair. Approximately 1 cm of tissue circumferentially beyond the edges of the fistula is needed to allow for tension-free closure.
- The order of closure depends upon the route of repair. If transvaginal repair, the bladder is closed first; if transperitoneal or transvesical, the vagina is closed first.
- Close the bladder with interrupted or running 3-0 or 4-0 delayed absorbable suture. Ideally, this first layer includes the lamina propria with or without the bladder mucosa.
- Retrograde fill the bladder to confirm watertight closure.
- Imbricate over the first layer of closure with interrupted or running 2-0 or 3-0 delayed absorbable suture. Ideally, this second layer includes the bladder muscularis.
- A third imbricating layer of the bladder peritoneum to further reinforce the repair may be possible using interrupted or running 2-0 or 3-0 delayed absorbable suture.
- Repeat cystoscopy if needed to ensure the following:
  - Intravesical hemostasis by irrigating with small volumes of fluid and removing blood clots that may obstruct catheter drainage.
  - Further confirm integrity of the repair by looking vaginally for spillage of cystoscopy fluid.
  - Absence of injury or obstruction to the ureter(s).
- Determine whether an interposition graft is needed (see text for details), and if performed, ensure adequate vascularity and stable interposition into the vesicovaginal space.
- Close the vaginal incision (vaginal side of the fistula) separately with interrupted or running 2-0 or 3-0 delayed absorbable

suture. If possible, avoid overlapping suture lines.

- Determine if a three-way transurethral Foley catheter is needed for postoperative bladder irrigation if there is concern for more blood clot formation at the completion of the case.

For larger, more complex fistulas, traditional VVF repair techniques may be needed, which involve similar steps as the Latzko technique, but the dissection is more extensive. Excision of the fistula tract may be performed if there is extensive scarring. If flap interposition is desired between the repaired fistula and the vaginal incision, common flaps used vaginally include Martius flap and peritoneal flap (see section “Tissue Interposition”).

## *Abdominal Approach (Open, Laparoscopic, Robotic) to Repair of Vesicovaginal Fistula*

Repair of VVF through the abdominal approach is indicated either for VVF that are inaccessible through the vagina or if there is need for concurrent transabdominal procedures, including ureteral reimplantation. The most common abdominal approach involves entering the peritoneal cavity with or without making an incision into the bladder to access the fistula tract (transperitoneal-transvesical, transperitoneal-extravesical). Another technique involves accessing the retropubic space and entering the bladder through an anterior cystotomy in order to repair the fistula (retropubic-intravesical). In addition to open surgery, minimally invasive techniques including laparoscopy, robotic-assisted laparoscopy, and laparoendoscopic single site have been used for these approaches.

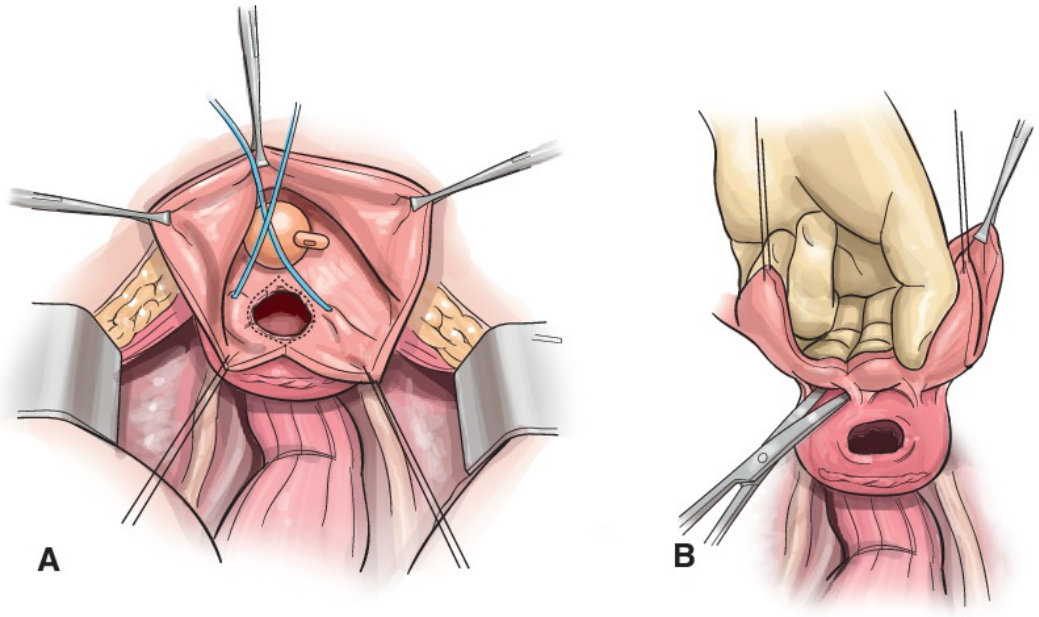
Most ureteral fistulas are successfully managed abdominally (open, laparoscopic, robotic) with recent case reports of transvaginal repairs in lower resource settings. The exact procedures used to repair ureteral fistulas or ureteral injuries depend on the location of the injury and how best to repair this area in a tension-free manner. Typically in VVF, the injury or the fistula is along the distal third of the

ureter, and a ureteroneocystostomy is indicated (see Chapter 37 for a more detailed discussion).

## Transperitoneal-Transvesical and Transperitoneal-Extravesical Vesicovaginal Fistula Repairs

The classic abdominal approach, popularized by O'Conor and Sokol, involves accessing the bladder transperitoneally and then bivalving the bladder starting at the anterior bladder down to the fistula tract (transperitoneal-transvesical approach). Specifically, once intraperitoneal access is obtained, the bladder is vertically bisected in the midline (**FIG. 35.2**). O'Conor and Sokol originally described starting the bladder incision at the anterior portion of the bladder, but a less extensive incision is possible (starting the bladder incision lower on the bladder, closer to the fistula tract so the resultant cystotomy is smaller [mini-O'Conor]) and may be used according to the specific circumstances and surgeon preference. The incision is continued to the posterior bladder until it reaches the vesicovaginal space. Sharply dissect into the vesicovaginal space to separate the bladder from the underlying vesicovaginal fibromuscular connective tissue until the bladder incision can be extended down to the fistula tract. The bladder is further dissected off the underlying tissue distal to the fistula tract until enough bladder tissue is mobilized to allow for tension-free closure. The vaginal epithelium is closed first. A second layer of the vesicovaginal fibromuscular connective tissue is used to imbricate over the first layer if possible. The entire bladder incision, which now includes the fistula tract, is closed in two layers, starting with the mucosa/lamina propria layer. The vagina and the bladder are typically closed in different directions (eg, vagina horizontally, bladder vertically). Bladder integrity is assessed via retrograde fill after the first-layer closure. If flap interposition is desired in the vesicovaginal space, commonly used flaps abdominally include the omentum (**FIG. 35.3**), sigmoid epiploica, and peritoneum. In anticipation of placing a flap, anchoring sutures are placed in the vesicovaginal fibromuscular connective tissue after the vagina is closed but prior to bladder closure. Once the bladder closure is complete and the flap has been developed, these sutures are

attached to the flap and tied down, securing the flap into the vesicovaginal space.



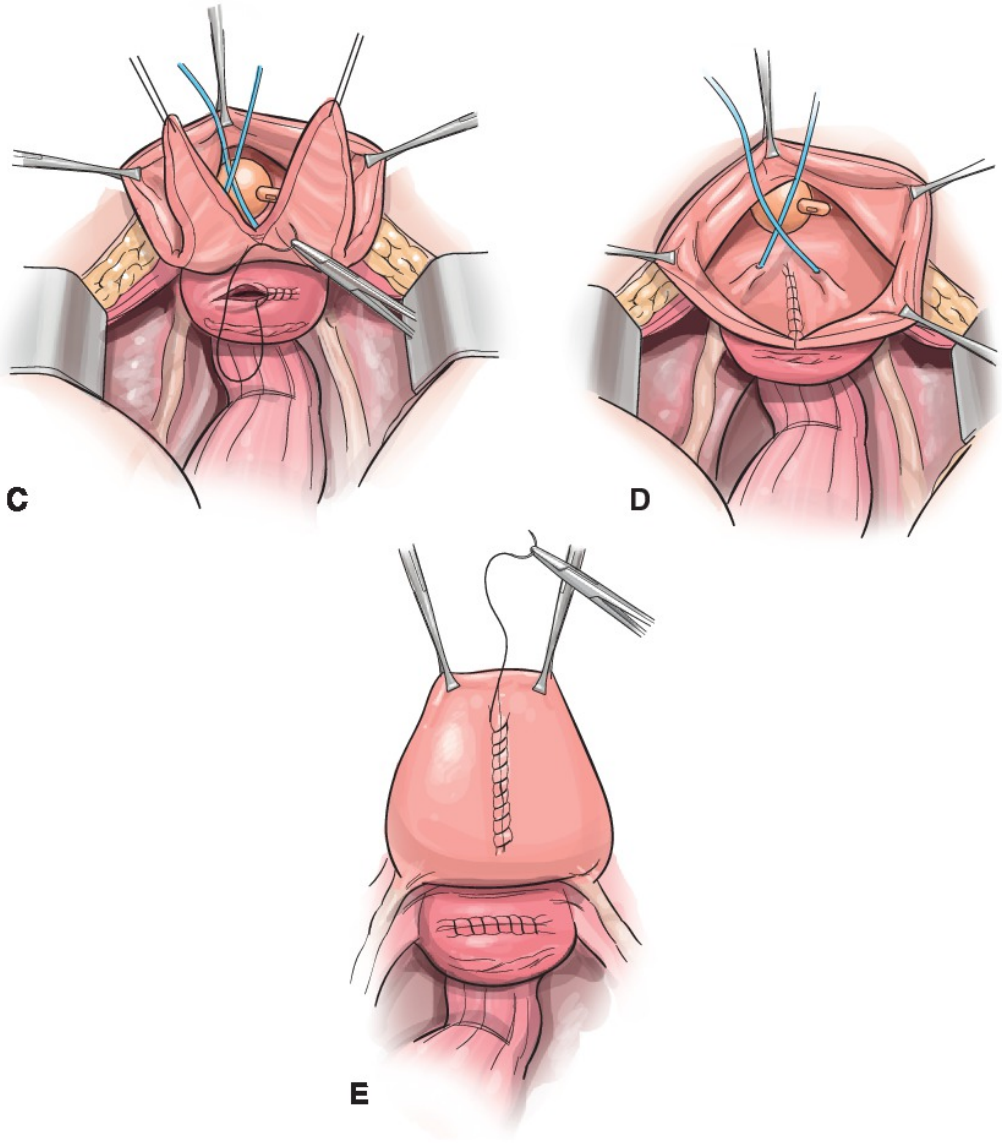



**FIGURE 35.2** Transperitoneal-transvesical vesicovaginal fistula repair. **A.** After the peritoneal cavity is entered, a midline incision is made in the anterior bladder, which is extended posteriorly until the fistula tract is reached. Ureteral stent(s) may be placed if needed. **B.** Dissection is continued in the vesicovaginal space distal (caudal) to the

fistula tract to allow for tension-free closure circumferentially. **C.** The vaginal epithelium is closed with interrupted or running suture. **D.** The bladder is usually closed with interrupted or running suture in two layers (first layer depicted here). **E.** A second layer is placed with interrupted or running suture (running suture depicted here).

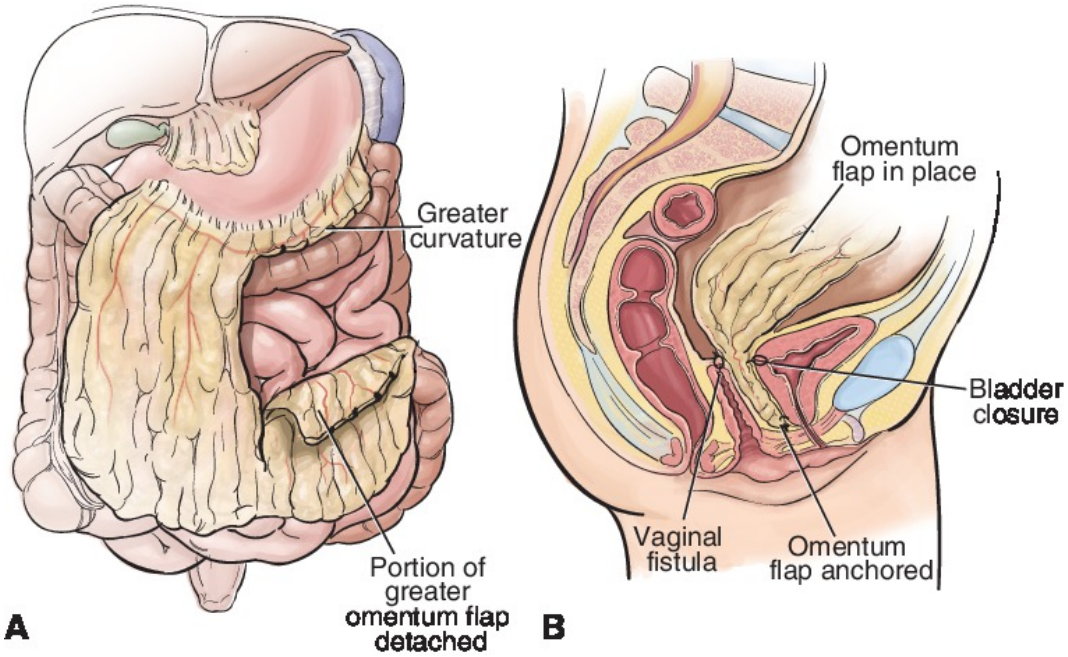



**FIGURE 35.3** Omental flap. **A.** The omentum is partially detached by securing its vasculature on the left along the greater curvature of the stomach. **B.** This results in extra length so the flap will reach the vesicovaginal space and is anchored by absorbable suture.

A transperitoneal-extravesical approach has also been described. In this approach, there is no separate cystotomy made into the bladder; instead, after the peritoneal cavity is entered, dissection is made directly into the vesicovaginal space until the bladder defect/fistula tract is reached and mobilized from the underlying vagina. The bladder and vagina are closed as above, bladder integrity is assessed, and interposing flap is placed as needed.

## Retropubic (Extraperitoneal)-Intravesical Vesicovaginal Fistula Repair

A modified abdominal approach, introduced by Landes, involves entering the bladder through an anterior cystotomy in the retropubic space (as opposed to the peritoneal cavity) without extending the cystotomy down to the fistula. Specifically, retroperitoneal (extraperitoneal) access is obtained by laparotomy, laparoscopy, or robotically. If a laparotomy approach is used, a midline abdominal wall incision or a transverse muscle splitting incision such as a Cherney or Maylard incision should be considered to facilitate exposure. Once the retropubic space is entered, vertical incision is created into the anterior bladder and extended until it is large enough to visualize the fistula through the cystotomy (**FIG. 35.4**). Similar to a transvaginal approach, a Foley catheter can be placed in the fistula tract through the anterior bladder cystotomy and balloon inflated in the vagina. Gentle traction is placed on the catheter to improve access and exposure of the fistula and surrounding tissue to facilitate dissection. If the fistula tract is too small in diameter to allow placement of a catheter, gentle dilation may be performed, or a small-caliber vascular catheter with an inflatable catheter balloon at the tip can be used. Intravesically, the fistula is circumscribed and dissected from the surrounding tissue within the vesicovaginal space. The fistula tract may be excised or kept *in situ* (as originally described by Landes) and the defect closed in layers starting with the vaginal layer. The vagina and the bladder are typically closed in different directions. Using the anterior cystotomy, the bladder is filled to check for integrity of the fistula repair while observing in the retropubic space and transvaginally. Alternatively, bladder integrity

can be checked after the anterior bladder cystotomy is closed by retrograde filling the bladder or cystoscopically.

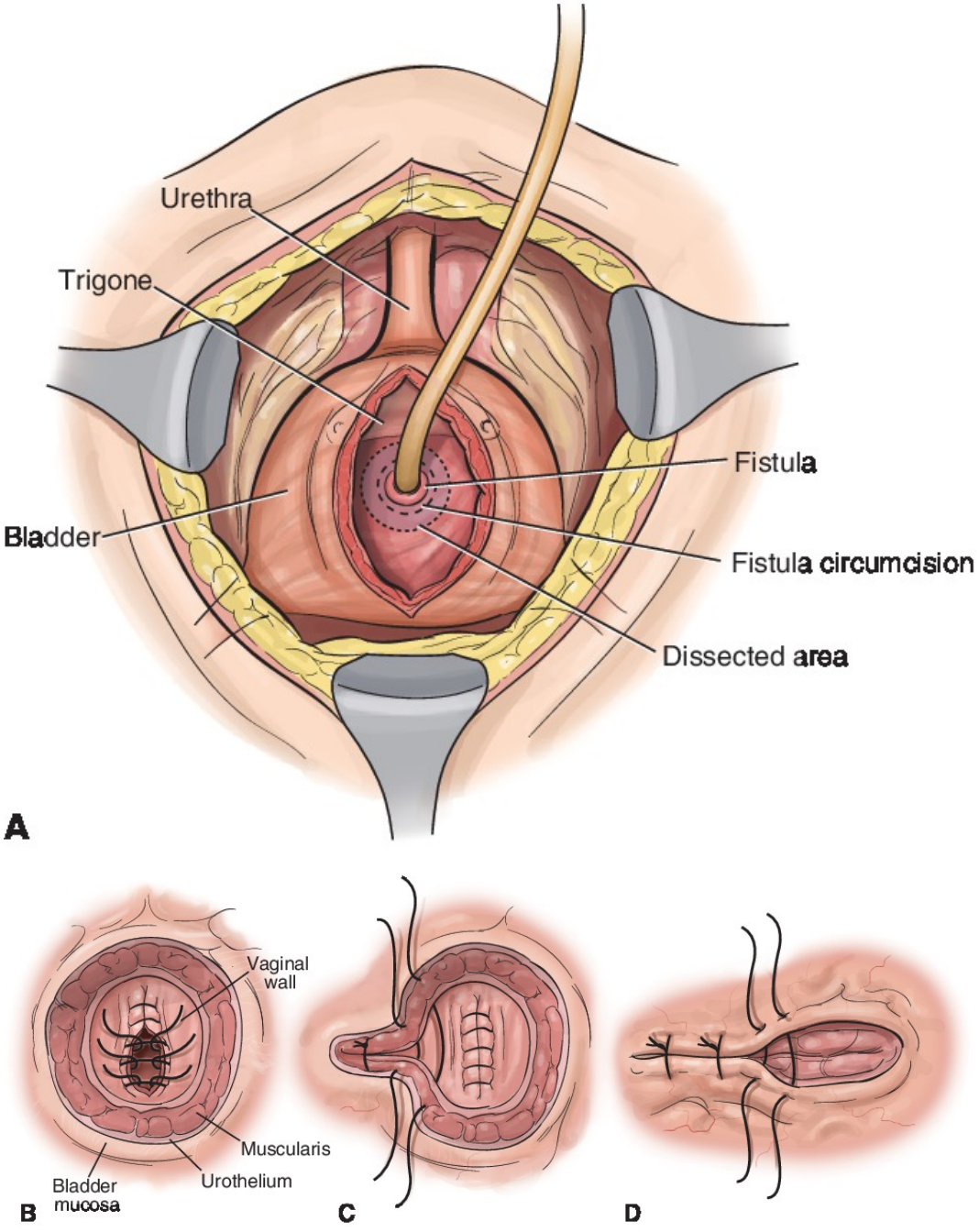



**FIGURE 35.4** Retropubic-intravesical vesicovaginal repair. **A.** After the retropubic space is entered, an incision is made in the

anterior bladder. The fistula is identified and circumscribed, and the vesicovaginal space is dissected circumferentially around the fistula tract. **B.** The fistula is shown with the vaginal epithelium, bladder muscularis, and urothelial layers. The first layer incorporates the vaginal epithelium using interrupted or running suture in a vertical orientation. **C.** The bladder muscularis is closed with interrupted or running suture in a horizontal orientation. **D.** The urothelial layer is closed with interrupted or running suture to complete the repair. The anterior bladder incision is closed.

When the fistula involves the pelvic ureter, or is near the ureteral orifice, ureteroneocystostomy may be needed. This is done prior to the closure of the bladder incision. To preserve as much ureteral length as possible, the ureter should be mobilized from the surrounding tissue and transected as close to the bladder or the injury site as possible. If there is tension at the site of reimplantation, additional procedures such as a psoas hitch or Boari-Ockerblad (Boari) flap can be created. A double-J stent is placed and left for 3-6 weeks. A Jackson-Pratt drain is placed near the anastomosis site and generally left overnight. For further discussion regarding these types of procedure, see Chapter 37.

Urethrovaginal fistulas that are located close to the external urethral meatus may be managed with an extended meatotomy where the fistula opening is extended to the external urethral meatus (similar to a Spence procedure used to marsupialize a distal urethral diverticulum). The edges of the urethral tissue can then be sutured to the vaginal epithelium. For a more proximal urethrovaginal fistula (**FIG. 35.5**), a transurethral Foley is placed and the fistula is

circumscribed (extending the incision longitudinally). The urethra is mobilized from the vagina; this dissection may extend laterally to the descending posterior pubic rami and anteriorly into the retropubic space in order to mobilize the urethra adequately. The surgeon may excise severe fibrosis/scarring. The urethral defect is then closed longitudinally with interrupted 3-0 or 4-0 delayed absorbable suture (around the Foley catheter) with care taken not to include the catheter in the closure. Additional imbricating layers are placed, utilizing the periurethral tissue previously exposed. As the urethra and periurethral tissue may be thin with limited blood supply, a flap interposition should also be considered to theoretically provide additional support and vascularity, particularly if there is significant scarring or if the fistula was recurrent or radiation induced. If there is evidence of stone or foreign material around the urethrovaginal fistula (eg, fistula that resulted from eroded polypropylene midurethral sling), these materials should first be removed.

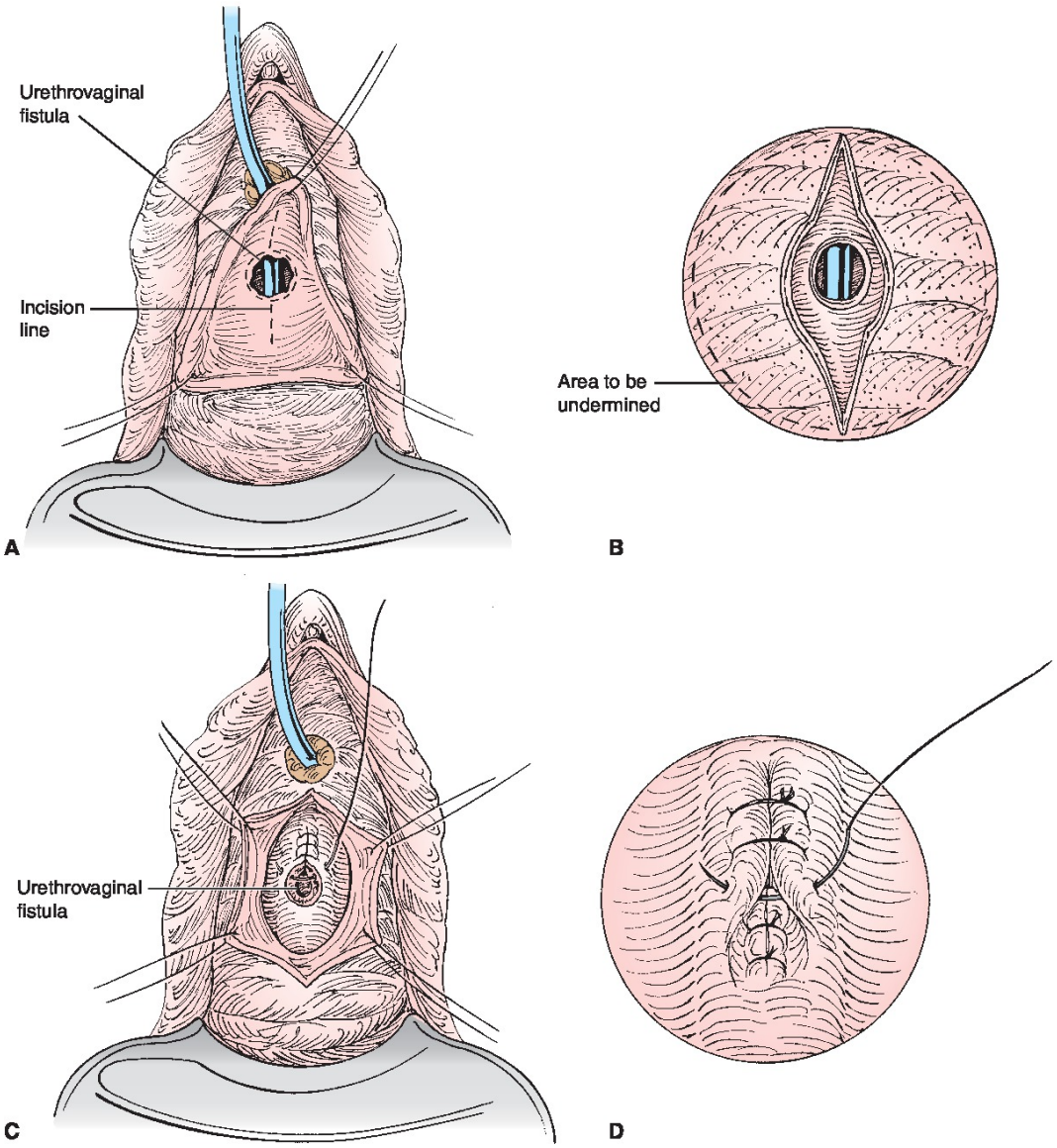



**FIGURE 35.5** Transvaginal approach to urethrovaginal fistula repair. **A.** Circumferential incision around the fistula tract with midline extension. **B.** Further lateral dissection exposes the periurethral tissue and allows for tension-free closure. **C.** Interrupted suture is used to close the first layer. **D.** The second layer imbricates over the first layer

with interrupted suture. Martius fat pad transposition is occasionally needed to further support these repairs. If not, the vaginal epithelium is closed to complete the repair.

### Urinary Diversion for Repair of Vesicovaginal Fistula

Most patients who require urinary diversion because of inoperable VVF have noncompliant bladders where there is extensive fibrosis of the bladder and surrounding tissue due to insults such as extensive damage from obstructed labor or pelvic radiation. In such cases, urinary conduits can be continent or incontinent and constructed from small or large bowel.

## *Postoperative Care after Vesicovaginal Fistula Repair*

Transurethral or suprapubic catheter drainage for 7-14 days is essential to avoid exerting tension on the suture line that would otherwise occur with a full bladder. Judgment should be exercised regarding duration of drainage, based on the extent of injury, its location, the security of the closure, and any factors that may impact the normal healing process. In the obstetric fistula literature, there are two randomized controlled trials evaluating fistula repair outcomes after 7 vs 14 days of postoperative continuous bladder catheterization and 10 vs 14 days of bladder drainage, which showed no significant differences in repair outcomes. A 2018 systematic review confirmed these findings and also found no differences in perioperative complications including rates of urinary tract infection, urinary incontinence, and urinary retention. The WHO put forth a recommendation in 2018 of 7-10 days for the duration of bladder drainage for simple fistula with a diameter of ≤3 cm located in the mid vaginal area with minimal scarring. For radiation-induced fistula, some experts have recommended continuous bladder drainage for at least 28 days. The use of antimuscarinic medications

or belladonna and opium suppositories may be needed to minimize discomfort associated with bladder spasms during the duration of catheter use. Additionally, some experts advocate performing a cystogram prior to catheter removal, and if repair success is not demonstrated, the catheter may be left in place for longer duration to promote continued healing. The utility of this additional test is uncertain, however, as subsequent VVF has been reported despite an apparently normal cystogram. A retrospective study of trauma-related bladder injury concluded that simple intraperitoneal bladder repairs do not require routine follow-up cystograms, while all extraperitoneal and complex intraperitoneal repairs require follow-up cystograms.

## *Surgical Outcomes: Vesicovaginal Fistula*

Most of the evidence on surgical outcomes of VVF is from case series in the obstetric fistula literature. Although many of these case series have large sample sizes, the follow-up periods are usually short (weeks to months) with significant losses of follow-up. The reported success rates vary (75%-95%) depending on the surgical technique and patient population; most series report success rates >80% with the highest rates of success in the initial repair. Anatomic characteristics that are associated with repair failure include severe vaginal scarring, small residual bladder size (large fistula), loss of urethra, circumferential fistula, and irradiated tissue. Other reported risk factors that may contribute to repair failure include surgeon's experience, local availability of health facility, patient's general health, and number of attempted repairs. In a case series of 541 obstetric fistula patients from Uganda with median follow-up of 3 months, the incidence of early failure (prior to hospital discharge) was 10.9% with risk factors for failure including fistula larger than 3 cm (adjusted odds ratio 3.12 [95% CI, 1.40, 6.93]), presence of foot drop (adjusted odds ratio 4.74 [95% CI, 1.88, 11.97]), the need for perioperative blood transfusion (adjusted odds ratio 3.10 [95% CI, 1.11, 8.66]), and stillbirth (adjusted odds ratio 3.71 [95% CI, 1.38, 9.96]). The incidence of late failure (median 3 months) for the 328

patients who presented for follow-up was 8.8% with risk factors for failure including stillbirth at the index delivery (adjusted odds ratio 4.63 [95% CI, 1.04, 20.51]) and previous fistula repairs (adjusted odds ratio 3.13 [95% CI, 1.30, 7.56]).

In a 2017 systematic review and meta-analysis of management of VVF in patients following benign gynecologic surgery, 98.0% of patients underwent surgical management with an overall success rate of 98.0% (95% CI, 96.1, 99.3). This review suggested comparable rates of success regardless of surgical approach: transvaginal repair (93.8% [95% CI, 90.0, 97.5]), transabdominal (97.1% [95% CI, 94.6, 99.2]), laparoscopic/robotic (98.8% [95% CI, 96.9, 100.0]), and combined transabdominal-transvaginal (90.7% [95% CI, 64.6, 99.9]). Approximately half of these patients (51.3%) received interposition grafts with success rates of 97.6% (95% CI, 93.6, 99.9). Complications included ileus, fever, intraoperative bleeding, wound infection, bowel injury, and vesicocolonic fistula. Only three of the included studies reported on long-term outcomes such as sexual activity, with most patients (76%) reporting being sexually active after surgery. In an analysis of 200 patient who underwent VVF repair (65% vaginal, 35% abdominal) in the American College of Surgeons National Surgical Quality Improvement Project database between 2006 and 2013, perioperative complications (within 30 days of surgery) occurred in 15% of patients, with urinary tract infections as the most common complication (8%) followed by blood transfusion (3%). Abdominal route of VVF repairs was an independent predictor of any perioperative complications and was more likely than the vaginal route to be associated with readmission (10.1% vs 0.8%), sepsis (4.3% vs 0%), and blood transfusion (7.1% vs 0.8%). Although the literature remains limited both for iatrogenic and obstetric fistula, the route of repair has not been consistently shown to impact postoperative sexual function while other factors that may play a role include fistula size and resultant vaginal caliber after fistula repair.

Success rates for the abdominal transperitoneal-transvesical approach have been reported between 86% and 100% for benign, nonirradiated fistulas. In data pooled from three studies reporting variations of the retroperitoneal-transvesical technique, with a total of

91 fistula patients (primary and recurrent), the success rate was 100%. In a series comparing a center's experience between vaginal and abdominal approaches for the repair of supratrigonal VVF, the rates of successful repair were comparable (94.8% vs 100%, respectively, *n* = 48). In a larger series of 124 patients who underwent abdominal repair of VVF (71.8% retropubic [extraperitoneal]-intravesical [all open] and 28.2% transperitoneal-transvesical [94.3% open, 5.7% robotic assisted]), the overall success rate was 98.4%. Success rates decreased with number of previous attempts at correction (second attempt: hazard ratio 1.61 [95% CI, 1.57, 1.98]; third attempt: hazard ratio 1.32 [95% CI, 1.25, 2.48]).

Several small case series on laparoscopic VVF repairs have been published. The vast majority of laparoscopic VVF repairs are transperitoneal-transvesical in the manner of a traditional O'Conor or modified O'Conor technique (mini-O'Conor). Reported success rates are comparable to the open approaches at 93%-100% with 8%-12% conversion rate to laparotomy with reported benefits inherent to a minimally invasive approach.

The experience in the literature regarding robotic-assisted laparoscopic repair of VVF is similarly dominated by small case series since the first case report by Melamud et al. in 2005. One of the larger case series included 73 patients who underwent robotic-assisted laparoscopic VVF repair via a transperitoneal-intravesical approach with interposition of either an omental flap or sigmoid epiploica in most repairs (72.7%). The success rate was 93.9% with a median follow-up of 35 months. Three patients also had concomitant ureteric compromise and required ureteric reimplantation with two patients requiring a Boari flap. In a retrospective study comparing open (20 cases) vs robotically assisted laparoscopic repair (12 cases) of recurrent VVF, the success rates were statistically similar (90% vs 100%) with significantly decreased blood loss and lengths of hospital stay in the robotic group.

A 2015 systematic review of laparoscopic and robotic-assisted transperitoneal VVF repairs, which included 44 studies consisting mostly of case series and case reports with a balance of transvesical

and extravesical approaches, showed overall success rates ranging from 80% to 100% with follow-up periods of 1-74 months. Both transvesical and extravesical approaches resulted in comparable rates of success irrespective of the number of layers used in fistula closure (single vs double) or the use of an interposition flap. Of note, 47.7% of studies described retrograde filling of the bladder with various volumes to assess repair integrity, and retrograde filling of the bladder was associated with a slight increase in repair success (99.3% vs 93.6%, relative risk 1.06 [95% CI, 1.01, 1.12]).

# *Urinary Incontinence*

In patients presenting with urinary incontinence symptoms after fistula surgery, it is critical to first confirm the lack of recurrent fistula. However, after successful closure of obstetrical VVF, 10%-55% of patients have reported persistent incontinence. Risk factors associated with incontinence after a successful fistula repair include urethral involvement (many experts believe at least 2 cm of urethra is needed to preserve continence), small contracted bladder (large fistula), increased vaginal scarring or fibrosis, and recurrent fistulas that have required multiple repairs. Urodynamic findings in small series of patients who reported incontinence symptoms after fistula repair included stress incontinence (31%-56%), stress and detrusor instability (37%-41%), and voiding dysfunction (4%-13%). In a more recent larger study of 149 patients who were referred for urodynamic testing after fistula repair, like other studies, most patients had stress incontinence (49% had stress incontinence; 43% had both stress incontinence and detrusor overactivity), and 3% had detrusor overactivity only. Women with persistent stress incontinence symptoms after repair of obstetric fistulas remain a surgical challenge. Many effective treatments for stress incontinence including midurethral slings may not be effective for this population due to the urethra being scarred and fixed (84%), and midurethral slings may be relatively contraindicated due to the increased risk of mesh erosion (20%). Surgical management reported in the literature for this population has included the use of autologous rectus or fascia lata slings as well as synthetic slings with similar rates of

symptom improvement (64%-90%) but higher risk of mesh erosion in the synthetic sling group. Periurethral injection of bulk-enhancing agents has also been reported.

# Surgical Repair of Rectovaginal Fistula

## *Abdominal Repair: High Rectovaginal Fistula Repair*

For fistulas at the very apex of the vagina (high rectovaginal or colovaginal fistula), an abdominal approach is generally required. Minimally invasive approaches (eg, laparoscopy, robotic-assisted laparoscopy) may be utilized successfully. This approach allows for resection of the involved bowel side of the fistula as in the case of diverticular disease, malignancy, or radiation-induced fistula.

Generally, colo- and enterovaginal fistulas develop in patients with previous hysterectomy when a pelvic abscess (from bowel inflammation/infection, such as diverticular abscess) forms a fistulous tract communicating into the vaginal cuff (**FIG. 35.6**). Diverticular disease is the leading cause of colovaginal fistula, followed by malignancy and inflammatory bowel disease. This process can also result in a fistula to the bladder (colovesical fistula). Division of the fistula tract, followed by bowel resection with primary reanastomosis, is often recommended. Some surgeons will also debride and reclose the vaginal cuff, although this practice is variable. Interposition of an omental flap (**FIG. 35.3**) can be helpful to avoid recurrence. In a retrospective study of 52 patients with diverticulitis-related colovaginal fistula at a tertiary referral center, concomitant ostomy construction and omental flaps occurred in 54% and 73% of repairs, which resulted in a fistula closure rate of 90%.

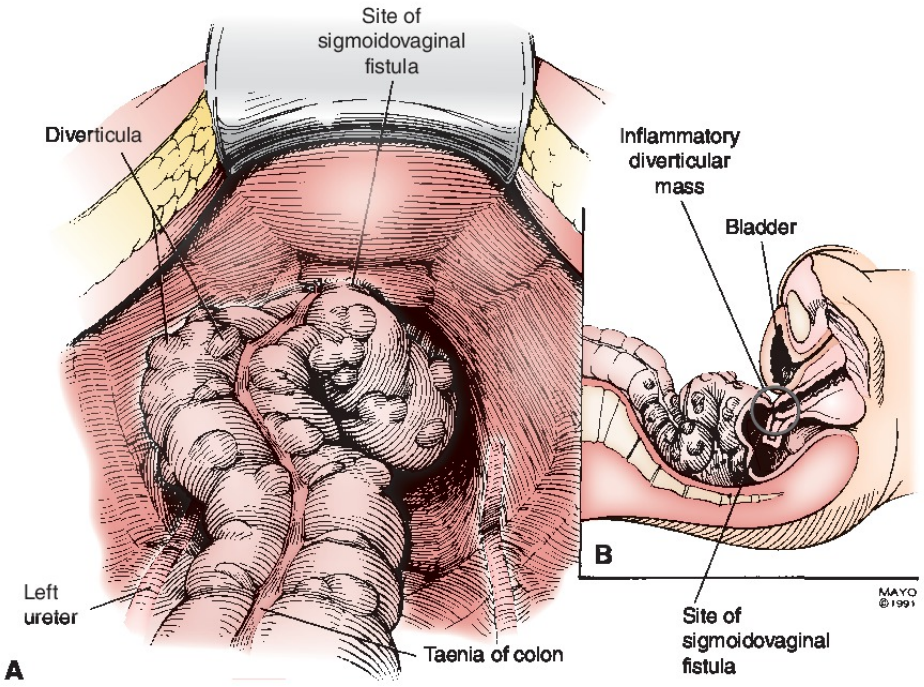



**FIGURE 35.6** High rectovaginal fistula. **A.** Sigmoid with multiple diverticula and site of sigmoidovaginal fistula. **B.** Site of sigmoidovaginal fistula at the apex of the vagina.

## *Transrectal or Transvaginal Repair: Midlevel Rectovaginal Fistula Repair*

A midlevel RVF is characterized by an intact perineum and anal sphincter, with the fistula located in the lower third of the vagina. These fistulas can be repaired successfully transperineally, transrectally, or transvaginally once the tissue has been cleared of infection and inflammation. Most gynecologists would perform a transvaginal layered closure with or without excision of the fistula tract (**BOX 35.2**) depending on the degree of local fibrosis/scarring (similar procedural tenets as vaginal VVF repairs). In contrast, most colorectal surgeons would perform an endorectal advancement flap

repair using a transrectal approach (FIG. 35.7). This latter approach theoretically has the advantage of repair of the higher-pressure side. Proponents of the transvaginal approach cite improved access/exposure, better vascularization of tissue, and an easier recovery (FIG. 35.8). Another recently described approach involves a stapled transperineal repair of RVF. Early experience suggests promising success and safety.

## BOX 35.2 STEPS IN THE PROCEDURE

### Transvaginal Rectovaginal Fistula Repair

- Circumscribe the fistula and sharply mobilize the anterior rectal wall from the posterior vaginal wall maintaining hemostasis and avoiding excessive tissue trauma.
- Continue to mobilize the vagina from the anterior rectal wall circumferentially around the fistula tract with sharp dissection using gentle traction on the vaginal wall and countertraction on the fistula tract. The surgeon's nondominant index finger can be placed in the rectum to aid in identification of the fistula, to support the rectal wall, and to facilitate dissection in the appropriate plane. A lacrimal duct dilator can also be placed in the fistula tract for better delineation.
- After there is enough tissue mobilized for tension-free closure, close the rectum with interrupted or running 3-0 or 4-0 delayed absorbable sutures. These sutures may be placed extramucosally and should include a portion of the muscularis and submucosa. Care should be taken to ensure the entire fistulous tract is closed by starting and ending this suture line at least 5 mm outside the apparent defect.
- Imbricate over the first layer of closure with interrupted or running 2-0 or 3-0 delayed absorbable suture, again beginning 5 mm outside the previous suture line, thereby inverting the first suture line into the rectum. This layer likely incorporates the rectovaginal fibromuscular connective tissue.

- If possible, place a third layer of interrupted or running 2-0 delayed absorbable suture imbricating the second layer.
- Determine whether an interposition graft is needed (see text for details), and if performed, ensure adequate vascularity and stable interposition into the rectovaginal space.
- If involved, lower portions of the puborectalis muscle and the external anal sphincter may be plicated to add an additional layer in the closure. Care should be taken that approximation is not carried so far superiorly that it results in a transverse band across the posterior vaginal wall, which may lead to dyspareunia.
- Close the vaginal incision (vaginal side of the fistula) separately with interrupted or running 2-0 or 3-0 delayed absorbable suture. If possible, avoid overlapping suture lines.

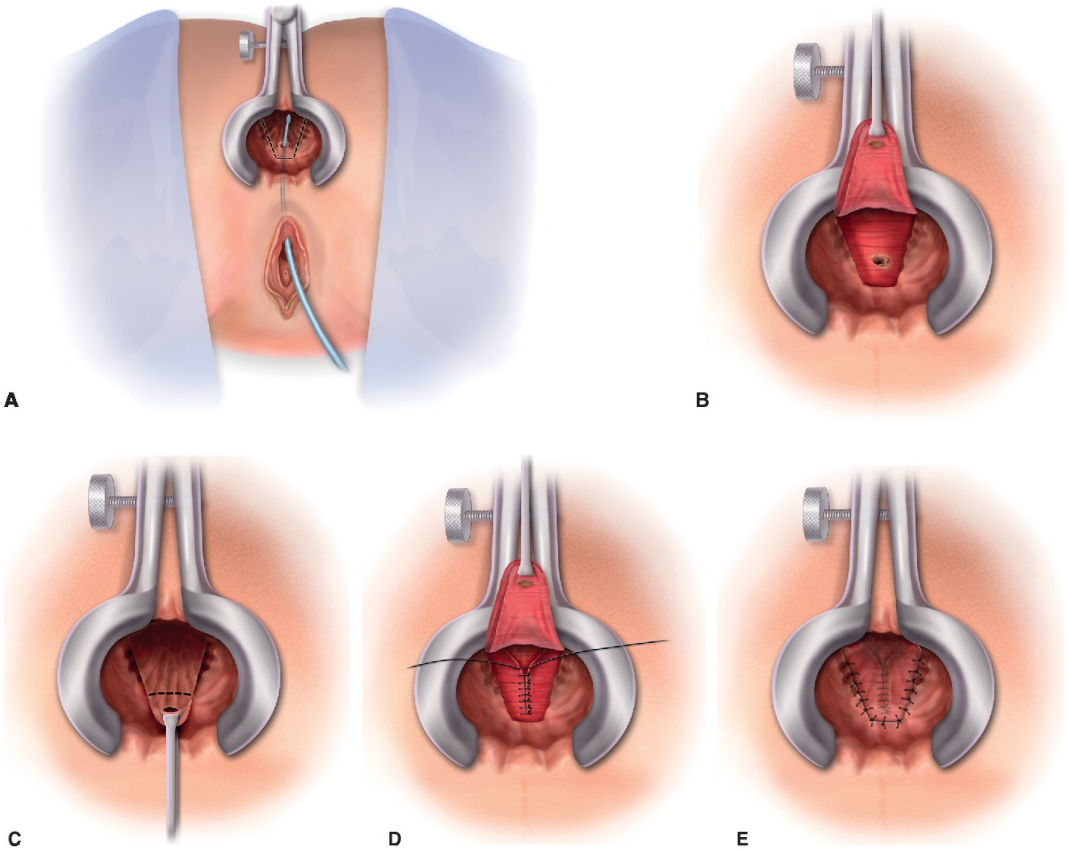


**FIGURE 35.7** Transrectal-endorectal advancement flap procedure. **A.** A probe demonstrates the rectovaginal fistula tract. **B.** A flap of rectal mucosa, submucosa, and the circular muscle layer is raised. **C.** Adequate mobilization of the flap to avoid tension. **D.** Reapproximate the muscular wall of the rectum over the fistula. **E.** The fistula tract is excised and the flap is advanced and sutured in place. (Reprinted with permission from Wexner SD, Fleshman JW. *Colon and Rectal Surgery: Anorectal Operations.* 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012. Figures 10.2, 10.4, 10.5, 10.8, 10.9.)

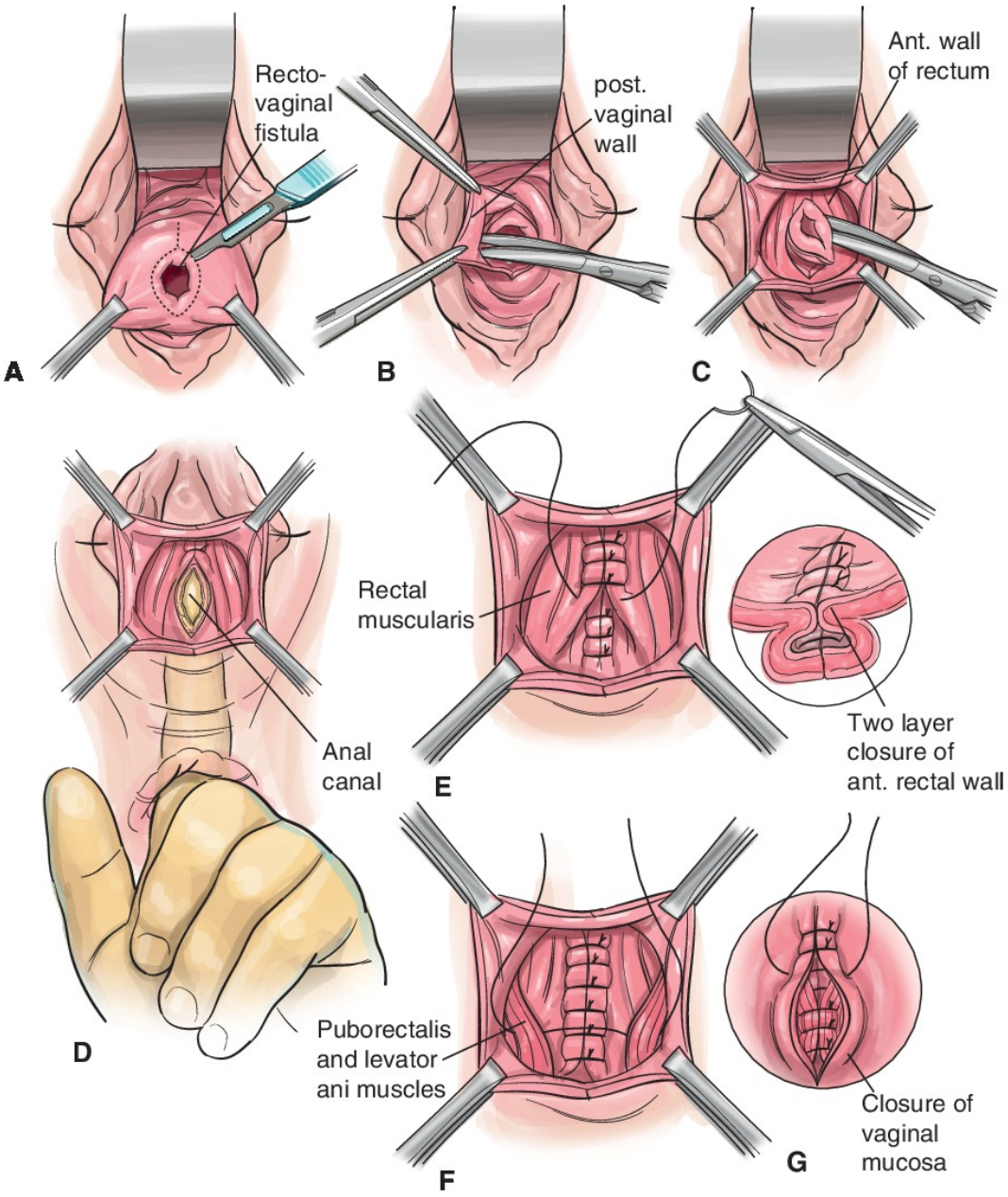



**FIGURE 35.8** Transvaginal rectovaginal fistula repair. **A.** Circumferential incision around the fistula tract with midline extension. **B.** Incision and mobilization of posterior vagina from the underlying anterior rectal wall. **C.** If there is fibrosis, the fistula tract may be excised sharply. **D.** Interrupted or running suture is

used to close the first layer. **E.** The second layer imbricates over the first-layer closure with interrupted or running suture. This may include plicating the internal anal sphincter. **F.** Plication of puborectalis and external sphincter (if applicable). **G.** Approximation of vaginal epithelium.

Endorectal flaps consist of the mucosal advancement flap, anocutaneous advancement flap, full-thickness advancement flap, and other variations of these techniques. Transrectal techniques may also include a layered closure but more typically utilize endorectal flap advancement (U-shaped wide-based flap, which is mobilized and advanced over the excised fistula tract) and anocutaneous flap advancement. Clinical practice guidelines in 2016 from the American Society of Colon and Rectal Surgeons still consider endorectal advancement flap the procedure of choice for most simple RVF, citing success rates ranging from 41% to 78%.

Choice of approach is, therefore, largely based on surgeon training and expertise, as both techniques appear to have similar success rates. Regardless of the surgical approach, the fistula tract should be excised if there is significant fibrosis. Also, augmentation with a flap such as the Martius flap (see section “Tissue Interposition”) should be utilized if there is concern for vascular compromise to the repair. Care should be taken to maintain hemostasis and closure of dead space to reduce the risk of hematoma formation that increases the risk of wound breakdown.

## *Transrectal or Transvaginal Repair: Low Rectovaginal Fistula Repair*

RVF located in the lower portion of the vagina and anal canal can be approached with either a transvaginal or transrectal operative repair.

Similar to midlevel RVF, gynecologists usually take a transvaginal approach, whereas colorectal surgeons prefer the transrectal technique. The transvaginal technique allows for a layered closure of the fistula and sphincteroplasty if needed with or without an episioproctotomy. Episioproctotomy is associated with excellent success rates for fistula closure, ranging from 78% to 100%. Furthermore, this procedure, although more extensive than simple transvaginal and transrectal advancement flaps, is associated with improved continence rates.

If the RVF is distal to the anal sphincter, transrectal simple fistulotomy may be selected; however, this procedure may still compromise the function of the anal sphincter.

The ligation of intersphincteric fistula tract (LIFT) procedure (**FIG. 35.9**), first described in 1993 for treatment of trans-sphincteric fistula, is yet another RVF surgical option and has been rapidly adopted as a first-line sphincter-sparing technique by many colorectal surgeons since being simplified in 2007. This procedure involves dissecting the avascular intersphincteric plane between the internal and external anal sphincters. The fistula tract is then identified, isolated, and divided on both sides between sutures. There has been recent growth in popularity of the treatment of low and perianal RVF using LIFT, particularly because the anal sphincter is preserved with this technique. A 10-year retrospective series from a single center of 116 patients who underwent a LIFT procedure noted a primary healing rate of 63%, and no change in manometric pressures (suggesting preservation of sphincter function) nor reported fecal incontinence. Additional bioprosthetic material may also be inserted if desired to separate the ends of the divided tract. For example, injection of platelet-rich plasma improved primary healing rates in a randomized trial of 98 fistula patients, which included this added intervention.

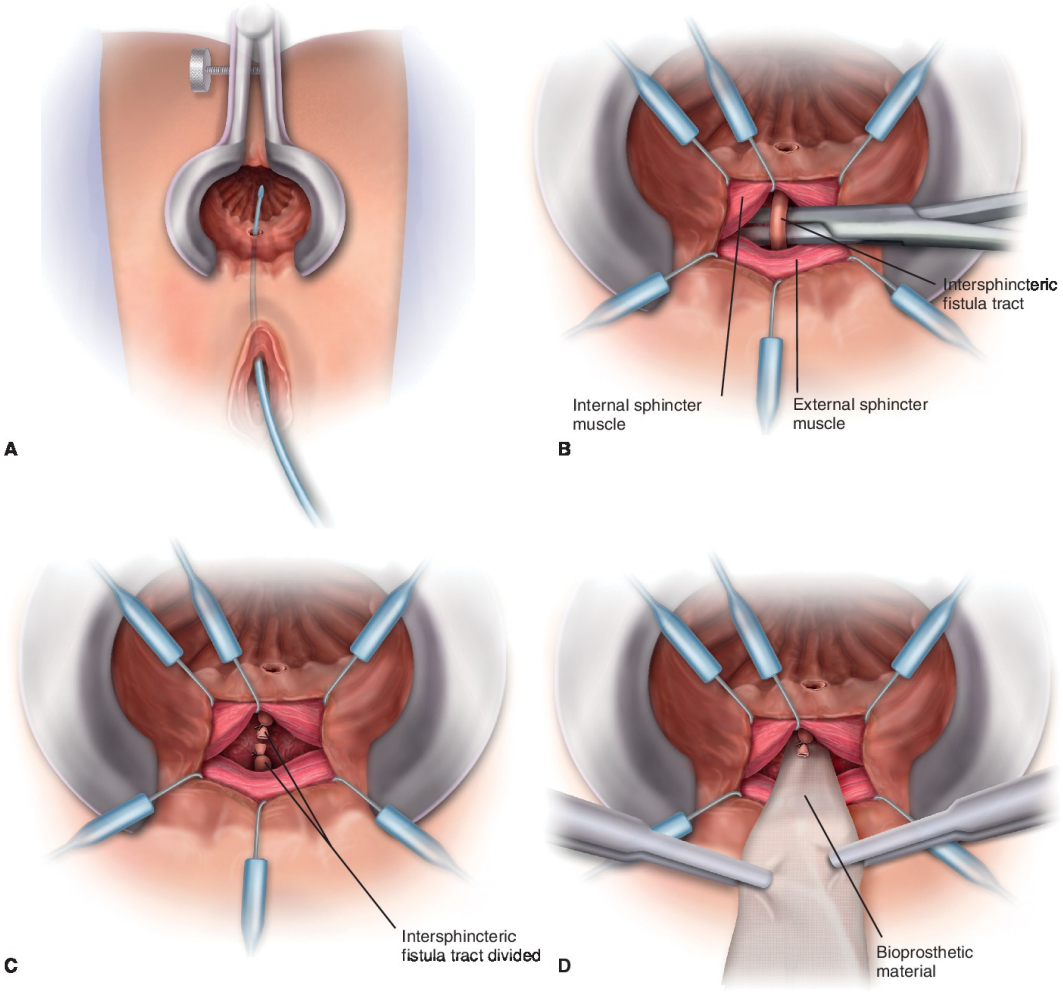



**FIGURE 35.9** Ligation of intersphincteric fistula tract procedure. **A.** Distal rectovaginal fistula tract is delineated using a fine catheter or probe. **B.** After dissecting the avascular intersphincteric plane between the internal and external anal sphincters, the fistula tract is identified and isolated. The fistula tract is depicted as an orange tube for the purposes of illustrating the technique. **C.** Tract is divided between sutures. **D.** Bioprosthetic material may be inserted between the separated ends

of the divided tract. (Reprinted with permission from Wexner SD, Fleshman JW. *Colon and Rectal Surgery: Anorectal Operations*. 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012. Figures 10.11, 10.12, 10.13, 10.14.)

For RVF in the lower third of the vagina that has concomitant perineal body and sphincter disruption, most gynecologists prefer conversion of the fistulous tract transvaginally to a fourth-degree laceration via an episioproctotomy. This procedure permits excision of the entire fistulous tract, if needed, followed by repair similar to that of a fresh fourth-degree perineal laceration (see Chapter 36). It has the advantage of a simultaneous sphincter and fistula repair. The technique requires transection and reunification of the external anal sphincter and the lower part of the internal sphincter. An overlapping or end to end external anal sphincteroplasty facilitates correction of anal incontinence (see Chapter 36). Concurrent repair of a disrupted sphincter at the time of RVF repair has been shown to improve fecal continence, and this information is discussed in more detail in the “Fecal Incontinence” section ahead.

## *Fecal Diversion for Repair of Rectovaginal Fistula*

Fecal diversion is utilized infrequently (7.3% of all RVF cases in a large national database study) but may be performed concurrently with RVF correction for several indications. Occasionally, RVF may be accompanied by local infection and abscess. In such cases, stool diversion may be necessary prior to RVF repair in order to achieve satisfactory symptom control and optimize tissue quality. Additionally, some experts recommend diversion of the fecal stream for prior failed repairs and/or with anticipated flap tissue transposition procedures to further promote successful repair. Although more

invasive and associated with higher complication rates, some experts advocate for abdominal resection with and without primary diversion and ileostomy takedown earlier, or even initially, due to the higher success rates. Lastly, in patients with recurrent failures, recalcitrant perineal inflammatory bowel disease, radiation-induced rectal stenosis, or significantly impaired fecal continence, a proctocolectomy and/or stoma may be used as the definitive treatment.

## *Postoperative Care After Rectovaginal Fistula Repair*

Most postoperative care recommendations are based on surgeon preference with limited evidence guiding practice. Although most experts would recommend optimal management of bowel consistency to avoid excessive straining or hard stool, some surgeons suggest a low residue diet and laxative stool regimen to keep the stool consistency liquid, while others recommend fiber supplementation and bowel regimen to keep the stool bulky. A randomized controlled trial of 66 patients undergoing elective fistula repair with primary sphincter reconstruction compared standard diet to an enteral resorbable diet with a peristalsis-inhibiting medication found no difference in healing rates, but higher satisfaction in the standard diet arm. As evidence is lacking for many of the postoperative restrictions often given to patients after any pelvic surgery (eg, soaking baths vs showering, restrictions on various physical activities including lifting), it is also important to consider how these factors may influence successful healing vs impact satisfaction with the recovery period.

## *Surgical Outcomes of Rectovaginal Fistula*

Abdominal approach to RVF has been associated with higher success rates than transvaginal/transrectal approaches in some series but has also been associated with higher rates of

complications. A 2017 retrospective cohort study of 107 patients undergoing their first surgical attempt at RVF repair found that those who underwent abdominal repair had significantly fewer recurrences at 1 year postoperatively regardless of the etiology of the fistula (5% for abdominal vs 45.4% for transvaginal/endorectal). However, these conclusions should be interpreted with caution due to the multiple differences among etiologies, routes, timing, and follow-up being compared in a retrospective manner.

Considerable experience exists with both the transvaginal and transrectal flap approaches to RVF repair; however, there are no comparative trials. A 2014 systematic review concluded that although there are many articles describing different operative techniques, the dearth of high-quality studies and lack of randomized controlled trials made it impossible to perform a meta-analysis and definitively recommend one approach over another.

Overall, the success rates for repair seem to be more related to the type of fistula than to the type of repair. A case series of 184 procedures including transrectal, transvaginal, and transperineal approaches with and without gracilis interposition, carried out in 125 patients with RVF of various etiologies, found that the overall success rate per procedure was 60% with no difference in recurrence rates based on type of repair. However, patients with Crohn disease were more likely to experience failures (44.2% success per procedure, 78% final success requiring an average of 1.8 procedures). Patients with obstetric injuries had a success rate per procedure of 66.7% and had an 89% eventual success rate requiring an average of 1.3 procedures per patient. Another retrospective case series of 124 patients with both primary and recurrent RVF undergoing a variety of RVF procedures (with and without flaps and diversions) in a colorectal surgery academic referral center demonstrated a 37.3% initial success rate, but a 73.4% success rate after the final procedure for their patients. This study confirmed findings of other publications that most RVF can be successfully treated but may require subsequent operations, and that etiologies such as prior radiation and Crohn disease confer lower success rates. Finally, a retrospective cohort of 88 patients who underwent RVF repairs with transperineal approach (multilayer,

with and without sphincteroplasty) found the only factor significantly associated with increased risk of failure was a nonobstetric etiology (RR 3.53 [95% CI 1.5, 8.32]). This last study differed from the prior studies, in that it had a larger obstetric cohort (60%) and only used one approach to repair, thus providing an even clearer picture of the relationship between etiology and failure. These case series demonstrate that patients with Crohn disease are more likely to experience repair failures than those with RVF of other etiology, with recurrence rates of around 50%. For patients with Crohn's-related RVF who are initially cured of RVF, the recrudescent nature of Crohn disease may make long-term failure rates higher. A case series of surgical repair of fistula related to Crohn disease, with an overall success rate of 46%, found that the use of immunomodulators within 3 months prior to surgery improved repair outcomes. Proctectomy and diversion is the definitive treatment for recalcitrant Crohn's-related RVF. In one case series of 32 patients with Crohn disease–associated RVF who underwent a total of 138 procedures and were followed for a median of 11 years, a diversion was ultimately required in 41% of patients.

Other risk factors for failure of repair frequently cited include prior surgical repair, steroids, and smoking. Emerging research also suggests that certain vaginal and rectal microbiome characteristics (eg, higher species diversity) are associated with fistula repair success.

Complications are not infrequent following RVF repairs and can include infection, thromboembolic events, readmission, and reoperation. A retrospective cohort study utilizing the American College of Surgeons National Surgical Quality Improvement Program database from 2005 to 2017 reported an overall complication rate of 13.2% following RVF repair (severe 7.9%, minor 8.4%). Although transabdominal repairs had the highest rates of complications (25.2% vs 15.8% in the transperineal approach vs 10.6% in the transvaginal/transrectal group), the only independent predictors of perioperative complications included inpatient status at the time of surgery and longer operating times. The most common postoperative complications included unplanned readmission (3.9%), postoperative superficial site infection (3.1%), and reoperation

(2.4%). The use of fecal diversion was not associated with complications. Of note, general surgeons performed the majority of the RVF repairs (87.4%) compared with gynecologists (12%).

## *Fecal Incontinence*

RVF repair does not guarantee continence. Because of the traumatic obstetric mechanism of injury most commonly leading to RVF, the incidence of concomitant fecal incontinence may be as high as 50%, and therefore fecal continence should be evaluated before initiating repair of the RVF. Patients with RVF should be questioned about symptoms of fecal urgency as well as degree of fecal incontinence. These additional symptoms often suggest disruption of the external anal sphincter. Such involvement of the anal sphincter may impact recommendations for treatment. Many patients with RVF from obstetric trauma will demonstrate sphincter defect with endoanal ultrasound.

If the anal sphincter or rectal reservoir is damaged, diminished sensation or control may result in continued loss of stool via the rectum rather than through the vagina. Concurrent repair of a disrupted sphincter at the time of RVF repair has been shown to improve fecal continence. A 2011 retrospective analysis of 87 patients undergoing episioproctotomy with anal sphincteroplasty vs rectal advancement flap for obstetric or cryptoglandular RVF found comparably successful healing (78% vs 62%) but significantly better fecal and sexual function in the episioproctotomy group. Specifically, in the episioproctotomy group, 50% of the patients had preoperative fecal incontinence with only 8% reporting fecal incontinence postoperatively; in the rectal advancement group, there were no significant changes in preoperative and postoperative fecal incontinence.

Furthermore, in cases of RVF related to radiation or Crohn disease, the rectum may remain noncompliant and, therefore, not function as a normal reservoir. The fecal incontinence experienced by these patients is not related to anal sphincter defects and, therefore, may not be amenable to surgical correction; preoperative

evaluation with anorectal manometry can provide useful information in this regard to assist in patient counseling.

# Tissue Interposition

The rationale for tissue interposition during fistula repair is discussed in detail above (section “General Principles of Fistula Repair”). Most surgeons would consider using an adjunctive flap if the fistula is recurrent or refractory, if the surrounding tissue is extensively scarred with impaired vascularity, or if the fistula originates from causes such as obstructed labor, radiation, or previous infection. Various vascular flaps have been described for both vaginal and abdominal approaches to lower reproductive tract fistula. Flaps used during vaginal repair include gracilis muscle, labial fat pad/Martius, rectus abdominis muscle, and peritoneum. Flaps used during abdominal repair include omentum (see **FIG. 35.3**), peritoneum, and sigmoid epiploica. Additionally, interposition using a variety of biologic materials such as fibrin has also been described.

Although the indications for flap augmentation are not well delineated, the Martius fibrofatty graft, first described in 1928, is one of the most commonly used flaps for vaginal augmentation of bladder and rectal fistulas (**BOX 35.3**). This flap is derived from labium majus muscle and fat. Theoretically, the majority of the blood supply comes from the inferior direction via the internal pudendal artery; however, there is sufficient blood supply present from both directions, leaving the point of flap detachment at the discretion of the surgeon. Most commonly, an inferior detachment is used to augment bladder/urethral repairs (**FIG. 35.10**) and a superior detachment is used to augment rectal repairs.

## BOX 35.3 STEPS IN THE PROCEDURE

### Development of Martius Fibrofatty Flap

- Close the bladder or rectal fistula vaginally as previously described.

- Make a 6- to 10-cm vertical incision over the labia majora.
- Deepen the incision sharply and bluntly to the level of the fat pad, which can be gently grasped with a Babcock or other atraumatic grasper.
- Sharply and bluntly isolate and mobilize the labial fat pad and/or bulbocavernosus muscle with care to maintain hemostasis as well as preserve the blood supply to the fat pad either superiorly or inferiorly. During the lateral and medial dissection, avoid being too superficial to prevent skin retraction and secondary deformation of the labium majus.
- Create a subcutaneous tunnel from the labium majus to the repair site under the labium and vaginal epithelium with curved Mayo scissors or a long curved clamp.
- Guide the free end of the flap through the above subcutaneous tunnel to the repair site with care not to twist the flap.
- Suture the flap to the surrounding tissue over the previously repaired site with interrupted 2-0 or 3-0 delayed absorbable suture.
- Ensure hemostasis in the flap and donor sites. Some surgeons advocate the use of a labial drain (Penrose or Jackson-Pratt), typically removed 24-48 hours postoperatively.
- Close the vaginal incision with running 2-0 delayed absorbable suture.
- Place deep layers of suture to reapproximate the resultant dead space in the labium majus with interrupted or running 2-0 or 3-0 delayed absorbable suture.
- Approximate the labial skin with interrupted or running 4-0 delayed absorbable, monofilament suture.

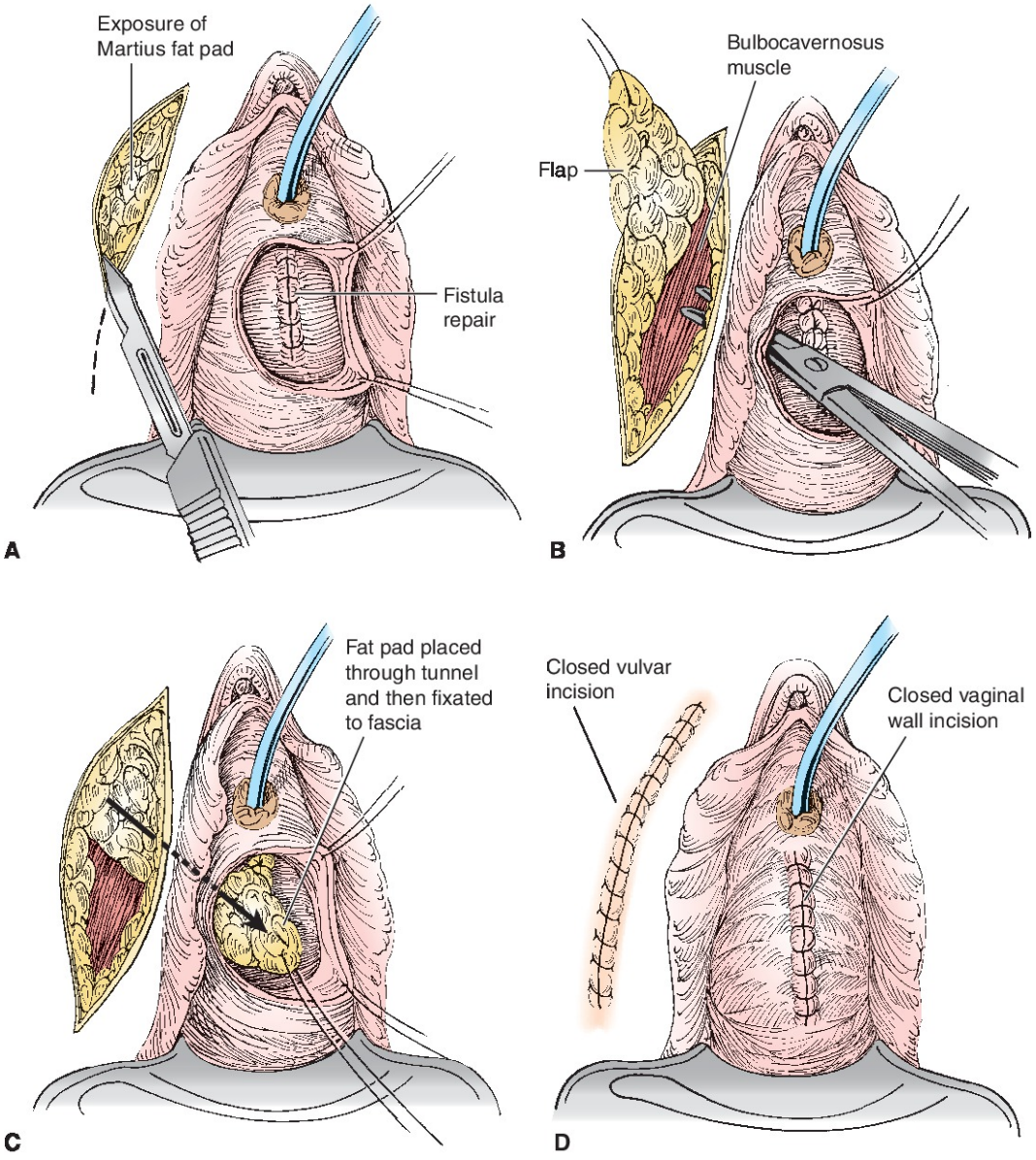



**FIGURE 35.10** Martius (bulbocavernosus) fibrofatty flap transposition. The flap is depicted here augmenting bladder repair, but it can also be used in a similar manner to augment rectal repair. The labial fat pad is supplied anteriorly by branches of the external pudendal and obturator arteries and posteriorly by branches of the internal

pudendal artery. Although traditionally the posterior blood supply was thought to be of superior quality, the graft may be swung anteriorly or posteriorly depending on the needs of the surgeon. Most commonly, an inferior detachment is used for anterior vaginal wall (augment VVF repair), and superior detachment is used for the posterior vaginal wall (augment RVF repair). **A.** An incision is made over the labial fat pad (in the labium majus), and it is dissected bluntly and with electrocautery ensuring adequate hemostasis and a continued adequate blood supply from the chosen pedicle. **B.** Once the blood supply is secured and labial fat pad is partially detached, a subcutaneous tunnel is created. **C.** The graft is guided through the tunnel to the previously repaired area. The graft anchored with interrupted suture. **D.** Hemostasis of the donor site is confirmed; the labium majus and vaginal epithelial incisions are closed.

In a small series of obstetric urethrovaginal and VVF repairs augmented with Martius flap, the success rates were high (87% and 100%, respectively). There is conflicting evidence as to whether graft augmentation does indeed result in improved success rates with one study demonstrating increased rates of success (70% vs 90%) and other studies showing similar success rates even in cases of

recurrent fistulas. Perioperative complications may be associated with the Martius graft, with one study reporting long-term complications (mean follow-up of 7 years) including pain (5%), numbness (14%), and distortion of the labia (7%). In a 2019 randomized controlled trial comparing Martius flap (*n* = 29) vs no flap (*n* = 28) in vaginal VVF repairs and omental flap (*n* = 35) vs no flap (*n* = 34) in abdominal VVF repairs, the authors found similar success rates in all groups with higher morbidities in the flap groups. Specifically, of the 29 patients who underwent Martius flap, 4 reported persistent pain and 5 reported numbness in the labia.

Many experts recommend the use of flap augmentation such as the Martius graft for repair of radiation-induced VVF. In a large series of 210 patients who underwent vaginal repair of these types of fistula, 41% of patients had vaginal repair augmented with Martius flap with an initial repair success rate of 48% and cumulative success rate (after multiple repairs) of 80%. For large fistulas or radiation-induced fistulas, a myocutaneous modification of the Martius graft has been described, which includes the bulbocavernosus muscle with or without the labial skin.

If a VVF is more cephalad and is near the vaginal apex/cervix, it may be possible to use a peritoneal flap. In one series with complex (>2 cm, radiation induced) or recurrent VVF repaired vaginally, the success rate with peritoneal graft augmentation was 96%, which was similar to the success rates of fistula repairs augmented with Martius flap in the same series (97%).

Additionally, other pedicles have been described including gracilis flap, as well as tubularizing the rectus abdominis muscle and placing it suburethrally (which was 100% successful in a small case series of six patients who failed urethrovaginal fistula repair with Martius transposition). One small randomized trial suggested similar success rates at 3 months between repairs augmented with fibrin glue vs Martius flap (68% vs 58%), with shorter operative time in the fibrin group. If there is extensive vaginal scarring and stenosis, a fasciocutaneous flap like a Singapore flap can be used, which contributes epithelial and subepithelial tissue to relieve tension in closure when needed.

Similar to VVF, various flaps and biologic grafts have been used to interpose between the vaginal wall and rectal mucosa after RVF repair with limited evidence demonstrating improved rates of success. The grafts have included gracilis muscle and Martius fibrofatty flap, as well as the use of a variety of biologic materials. Many experts recommend a diverting ostomy as an adjunct to complex muscle flap–augmented repairs of RVF to optimize outcome.

Martius flaps are best used to augment low- and midlevel RVF in the distal 5 cm of the vagina. A cohort of 24 patients with either two previous RVF repair failures or chronically inflamed tissue who underwent Martius flap (along with fecal diversion) for low RVF noted a success rate of 91%. Furthermore, the authors reported no major complications with improvements in quality of life and sexual function on validated questionnaires.

Gracilis muscle interposition offers a greater bulk of healthy vascularized tissue to facilitate tissue healing. In this procedure, the gracilis muscle is harvested from the thigh, mobilized on a proximal pedicle maintaining its femoral blood supply, passed through a tunnel at the proximal aspect of the thigh toward the perineum, and interposed between the rectum and vagina. Despite promising success rates for patients who have generally failed other repairs, there is greater morbidity with this procedure, including dyspareunia. In one of the largest series to date, failure rates of graciloplasty for 61 patients with recurrent RVF ranged from 30% for obstetrical RVF to 43% in the case of Crohn disease–related RVF. Postoperative perineal infection was a risk factor for graciloplasty failure, and postoperative antibiotic prophylaxis reduced the risk of failure to <15%. Another large series of 59 patients over a 20-year period who underwent a variety of flaps, but predominantly gracilis, for complex and recurrent rectovaginal or rectourethral fistula at a tertiary hospital system noted a success rate of 51.5%, and a complication rate of 59.1%. Complications included recurrence (37.8%), infection (21.2%), and flap dehiscence (16.7%). Smoking, BMI > 35 $kg/m^2$, and fistulas due to cancer were risk factors for complications.

Biologic grafts have recently been examined as possible interposition adjuncts to improve rates of RVF closure. The

advantage of these materials is that no flap harvesting is necessary. Several different types of grafts have been evaluated in small case series or case reports including acellular porcine dermal graft, porcine small intestinal submucosa, and acellular human matrix. The role of bioprosthetics in augmenting healing after RVF repair remains unknown, and although early reports from small series of repairs augmented with biological mesh showed encouraging results, continued demonstration of their impact in trials has not come to fruition. Further studies to assess their advantage compared with traditional surgical techniques are needed to define their place in the surgical armamentarium.

# KEY POINTS

- In lower resource settings, vesicovaginal fistulas most commonly result from obstructed labor, while in higher resource settings, these fistulas are iatrogenic, most commonly the result of complications of pelvic surgery.
- Rectovaginal fistulas most commonly result from obstetric trauma in both higher- and lower-resource settings, but other important causes include inflammatory conditions such as Crohn disease and pelvic surgery.
- Prior to surgical treatment of suspected iatrogenic bladder fistulas, radiographic evaluation of the ureters should be undertaken.
- The incidence of concomitant fecal incontinence in obstetric rectovaginal fistulas is high, and therefore assessment of the anal sphincter should be undertaken prior to surgical intervention.
- Although conservative management options can be considered for both genitourinary and rectovaginal fistulas, most pelvic fistulas will require surgery.
- Routes of repair of bladder fistulas include transvaginal or transabdominal (laparoscopic, robotic). Vaginal repair is typically the preferred repair approach unless the fistula is not accessible

vaginally or the patient requires concomitant abdominal procedures.

- Routes of repair of rectovaginal fistulas include transvaginal, transrectal, or transabdominal (laparoscopic, robotic). The route chosen depends upon the surgeon's expertise; the status of the anal sphincter; the etiology, size, location, and accessibility of fistula; the need for flaps or colorectal diversion; and whether prior surgical corrections have failed.

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# CHAPTER 36

# REPAIR OF EPISIOTOMY AND COMPLEX PERINEAL LACERATIONS

Dana R. Gossett and Christina Lewicky-Gaupp

**Episiotomy**
Incidence
Indications
Mediolateral and Midline Episiotomy
Technique: Mediolateral Episiotomy
Primary Episiotomy Repair
**Complications of Episiotomy**
Extension
Hematoma
Infection and Dehiscence
**Obstetric Anal Sphincter Injuries**
Incidence and Risk Factors
Technique of Primary Repair
Postpartum Management of OASIS
Complications of OASIS
Delayed Repair of OASIS

# EPISIOTOMY

An episiotomy is a surgical incision of the perineal body performed to facilitate vaginal delivery. Episiotomy was first described in 1742 and introduced to American obstetric practice in the 19th century. However, it became much more common in the United States after 1920, when prominent obstetrician Joseph DeLee promoted it in a landmark lecture given at the American Gynecologic Society. DeLee advocated the use of mediolateral episiotomy in all nulliparous women, as well as what he termed “prophylactic forceps” for delivery. The rationales for episiotomy included shortening of the second stage, preservation of the pelvic floor, prevention of uterine prolapse, and avoidance of “rupture of the vesicovaginal septum and the long train of sequelae” that follow. He also argued that by expediting delivery, obstetricians could reduce the rate of short- and long-term damage to infants.

## Incidence

By the end of the 1970s, episiotomy was performed in 63% of all vaginal deliveries in the United States, with higher rates among nullipara. However, physicians began to question the purported benefits to both mother and newborn during the 1970s and 1980s. As a result, the incidence of episiotomy has decreased significantly. The contemporary episiotomy rate in the United States is currently between 9% and 12%.

## Indications

The initial rationale for episiotomy use included improved neonatal outcomes and decreasing trauma to the maternal pelvic floor, as well as improved ease of repair compared to spontaneous lacerations. However, these purported benefits have not been borne out by evidence. What, then, are modern indications for the performance of episiotomy? Two compelling indications remain—both of which benefit the fetus in an emergent situation. First, episiotomy can be of value if a fetal bradycardia occurs as the fetal head is crowning,

because performance of the episiotomy can expedite delivery. Second, episiotomy can be useful when managing a shoulder dystocia, in order to allow greater space for the accoucheur's hand to perform rotational or other corrective maneuvers. It is important to note that episiotomy alone will not correct a shoulder dystocia as the greater soft tissue space will not disimpact the anterior shoulder from the maternal pubic arch—thus, episiotomy is useful only when the operator judges that she/he needs additional space for the necessary maneuvers. Episiotomy is not indicated for routine use in operative vaginal deliveries and further increases the risk of severe perineal injury when used in combination with vacuum or forceps assistance.

## Mediolateral and Midline Episiotomy

When an episiotomy is deemed clinically necessary, available evidence would suggest that a mediolateral incision incurs less risk of anal sphincter injury than midline episiotomy. Historically, mediolateral episiotomy has been associated with a greater risk of dyspareunia than midline episiotomy. Mediolateral episiotomy may also cause greater blood loss and increased risk of perineal hematoma formation and may be technically more difficult to repair. However, no large high-quality studies have directly compared the two techniques. A recent study assessed pelvic floor pain and dyspareunia in a nonrandomized group of patients after delivery with episiotomy. The investigators found no differences in pain on postpartum day 1 or 3 months postpartum, and no differences in reported dyspareunia, based on episiotomy technique. Thus, historic rationales for a midline approach may need to be reconsidered, and further study directly comparing the techniques would be useful to understand the relative risks and benefits of each.

One reason for the mixed data regarding perineal outcomes after mediolateral episiotomy may be that many "mediolateral" episiotomies are improperly performed. Several studies in the United Kingdom have shown gaps in the techniques of physicians and midwives in episiotomy technique. One study in 2003 demonstrated that only 46% of physicians and 33% of midwives were able to draw

a pictogram of an “ideal” episiotomy—one that is at least 40° off the midline. A subsequent study examined intended “mediolateral” episiotomies after repair and found that only 22% of episiotomies performed by physicians were mediolateral (between 40° and 60° off the midline); none of those performed by midwives were mediolateral. A true mediolateral episiotomy starts at the midline (7 o’clock position of the vaginal introitus) and extends posterolaterally at a minimum of 45° from the midline. It is important to remember that the perineum is distended around the fetal head at the time of crowning and therefore the angle is distorted. For this reason, the angle of the incision will appear to be ~60° when the incision is being made. More recent work has shown improvements in technical knowledge but still wide variation in the intended angle of mediolateral episiotomy. In addition, novel devices have been created to ensure a correct angle is incised, though none has achieved widespread use.

# Technique: Mediolateral Episiotomy

Most right-handed accoucheurs perform a right mediolateral episiotomy. The incision should be made starting at the 7 o’clock position and extending toward the ischial tuberosity. The angle of the incision should be ~60° to the midline on the distended perineum. The incision is made with straight or curved scissors, with the inner blade inside the vaginal introitus and the outer blade along the perineum. The length of the incision is based on the judgment of the operator as to how much additional space is needed to accomplish delivery—on average, this is between 2.5 and 3 cm.

Recommendations regarding the timing of episiotomy have not been subject to rigorous study and are largely based on expert opinion. Most such recommendations date from the era when routine episiotomy was recommended, and experts advocated for “early” episiotomy, prior to crowning of the fetal head. However, in the modern era of restrictive episiotomy use, the indications for episiotomy do not generally arise until crowning has occurred. One study examining the risks of episiotomy prior to crowning vs after crowning showed no differences in blood loss, pain, anatomic

outcome, anal sphincter injury, sexual function, or anal incontinence. In most cases, episiotomy is now performed once the head is crowning (3-4 cm visible with a contraction).

The location of both mediolateral and midline (median) episiotomy incisions are illustrated in **FIGURE 36.1**. Given the clear association of midline episiotomy with increased rates of anal sphincter laceration, strong consideration should be given to a mediolateral approach.

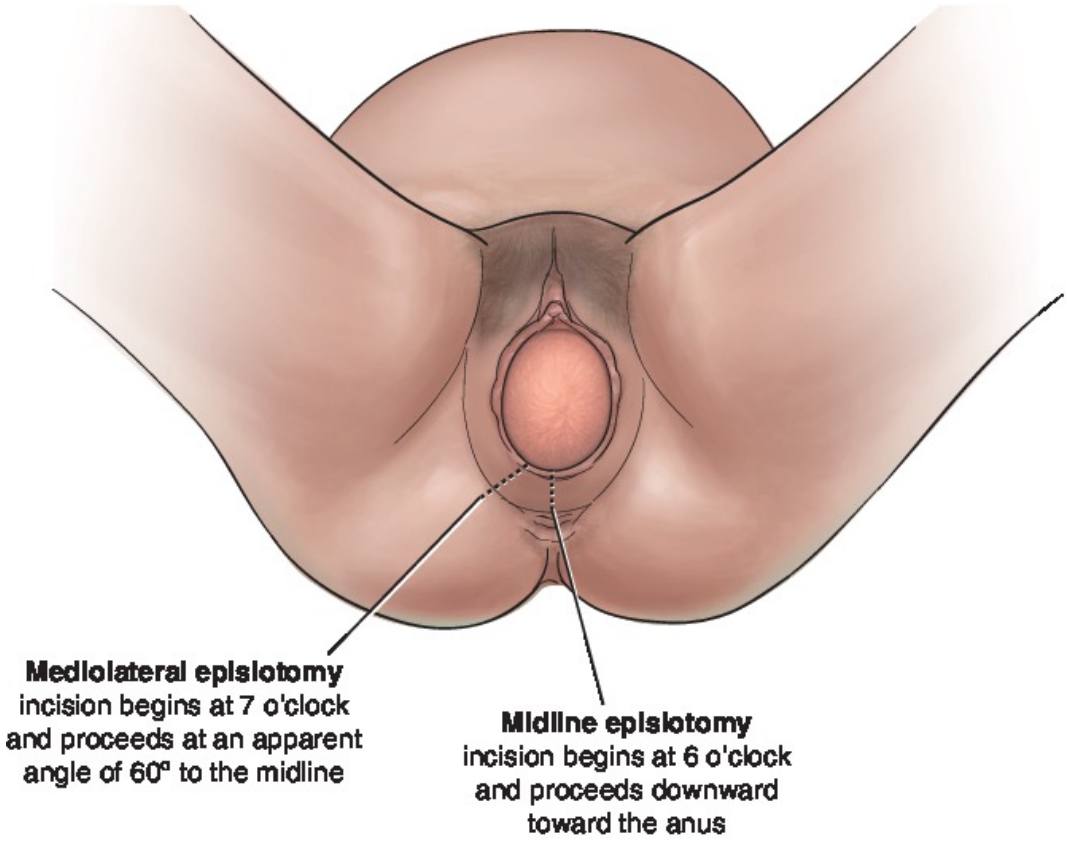



**FIGURE 36.1** Mediolateral and midline episiotomy. The midline episiotomy begins at 6 o'clock and proceeds downward toward the anus. The mediolateral episiotomy begins at the 7 o'clock position and proceeds at an apparent angle of 60° from to the midline.

# Primary Episiotomy Repair

Use of a 2-0 rapidly absorbable polyglactin suture (Vicryl Rapide) is associated with less pain than polyglactin and less need to remove extruded or persistent suture during the healing process. Repair of an uncomplicated episiotomy is performed in similar fashion to the repair of a spontaneous second-degree perineal laceration (**FIG. 36.2**). First, an anchoring stitch is placed at the vaginal apex of the episiotomy and tied. The vaginal mucosa and submucosal tissue are then closed in a running, locked fashion to the level of the hymenal ring; the hymenal ring should be reapproximated with the same suture. Next, the fascia and muscles (transverse perinei and bulbospongiosus) are repaired with a nonlocking suture. Anatomic result may be better with interrupted sutures compared to running suture, though this is more time consuming and may be associated with more postpartum pain. An additional, more superficial layer of suture may be required to optimally approximate the skin edges. Finally, the perineal skin is closed with 3-0 or 4-0 absorbable suture in running subcuticular fashion (**BOX 36.1**).

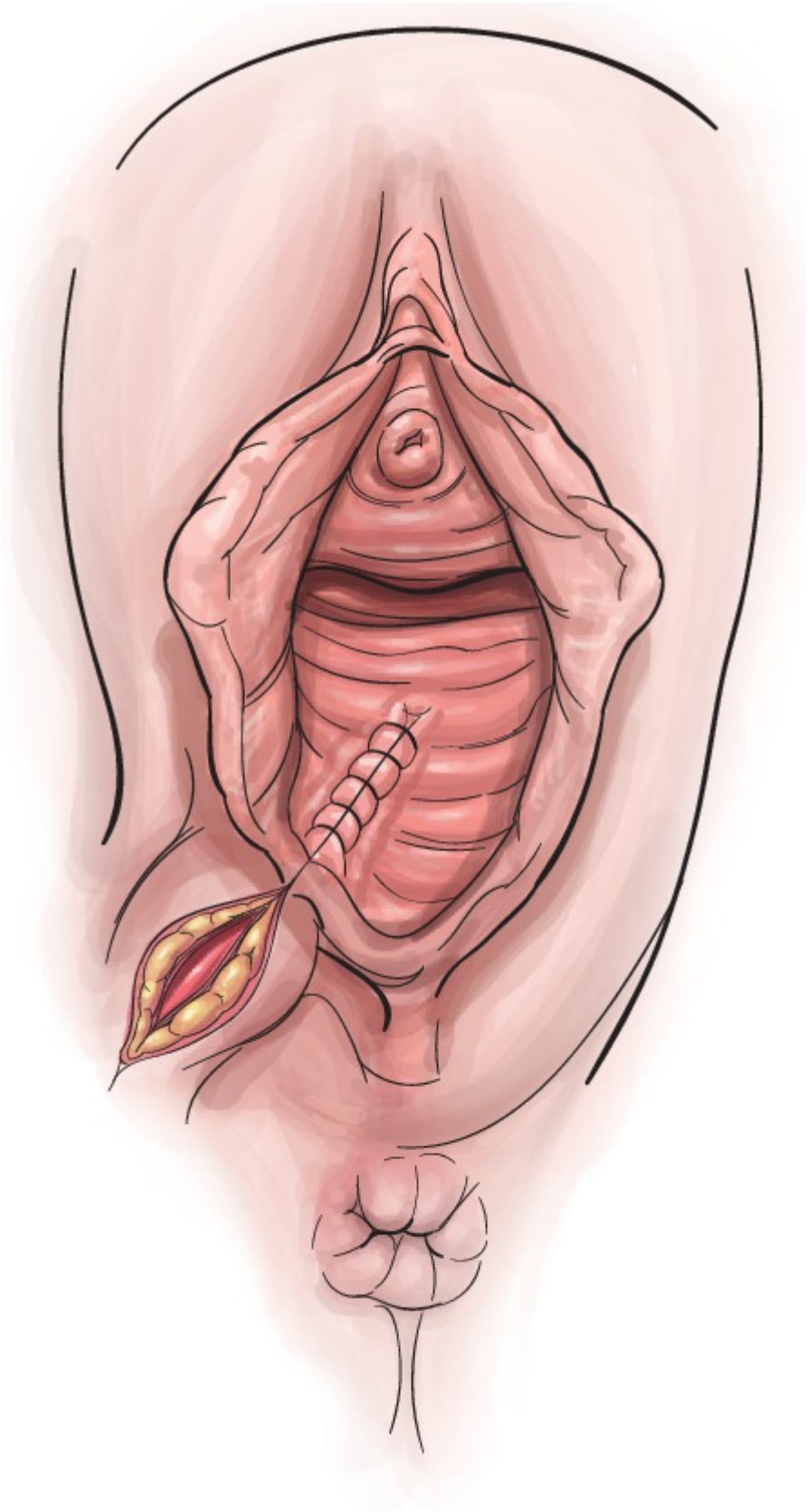


**FIGURE 36.2** Repair of mediolateral episiotomy: the vaginal mucosa has been reapproximated and the hymenal ring repaired. The muscular layer must now be repaired.

## BOX 36.1 STEPS IN THE PROCEDURE

### Episiotomy Repair

- Identify the apex of the vaginal incision. Close the vaginal mucosa to the hymenal ring with a continuous running locked suture of 2-0 absorbable suture.
- Close the fascia and muscles of the pelvic floor with 2-0 absorbable suture. Anatomic result may be better with interrupted sutures compared to running suture, but continuous suture is more rapid and may cause less pain.
- An additional, more superficial layer of suture may be required to optimally approximate the skin edges.
- Close the perineal skin with 3-0 or 4-0 absorbable suture in running subcuticular fashion.

# COMPLICATIONS OF EPISIOTOMY

## Extension

A correctly performed episiotomy provides the anatomic equivalent of a second-degree perineal laceration—incising the vaginal mucosa and perineal skin as well as the underlying musculature. However, as noted above, extension to the anal sphincter can occur, resulting in a third- or fourth-degree extension of the episiotomy. Rates of sphincter injury vary with both patient-level factors and obstetric

variables. Known patient risk factors for sphincter injury include Caucasian and Asian races, nulliparity, age over 30, higher birth weight, and occiput posterior position. In addition, prolonged second stage of labor, operative vaginal delivery (forceps, vacuum), and midline episiotomy increase the risk of sphincter injuries. Further discussion of the repair of sphincter injuries can be found later in this chapter.

## Hematoma

Mediolateral episiotomy is associated with greater blood loss than midline episiotomy; this is due to transection of muscle tissue and to possible transection of the lateral medial labial arteries or the internal pudendal vessels. The presence of these vessels increases the risk of hematoma formation after completion of the repair. Small hematomas can be managed conservatively with pain control, topical application of ice, and close observation to ensure that the hematoma does not continue to expand. Large or expanding hematomas will require takedown of the episiotomy repair, evacuation of the hematoma, and secondary repair. Although it is uncommon at the time of hematoma evacuation to identify an actively bleeding vessel, should a vessel be identified, it should be ligated prior to secondary closure.

## Infection and Dehiscence

Infection and dehiscence after uncomplicated episiotomy is very rare. Antibiotic prophylaxis is not warranted for episiotomy without extension. When extension into the anal sphincter occurs, this is managed similarly to a spontaneous sphincter injury (discussed further below).

# OBSTETRIC ANAL SPHINCTER INJURIES

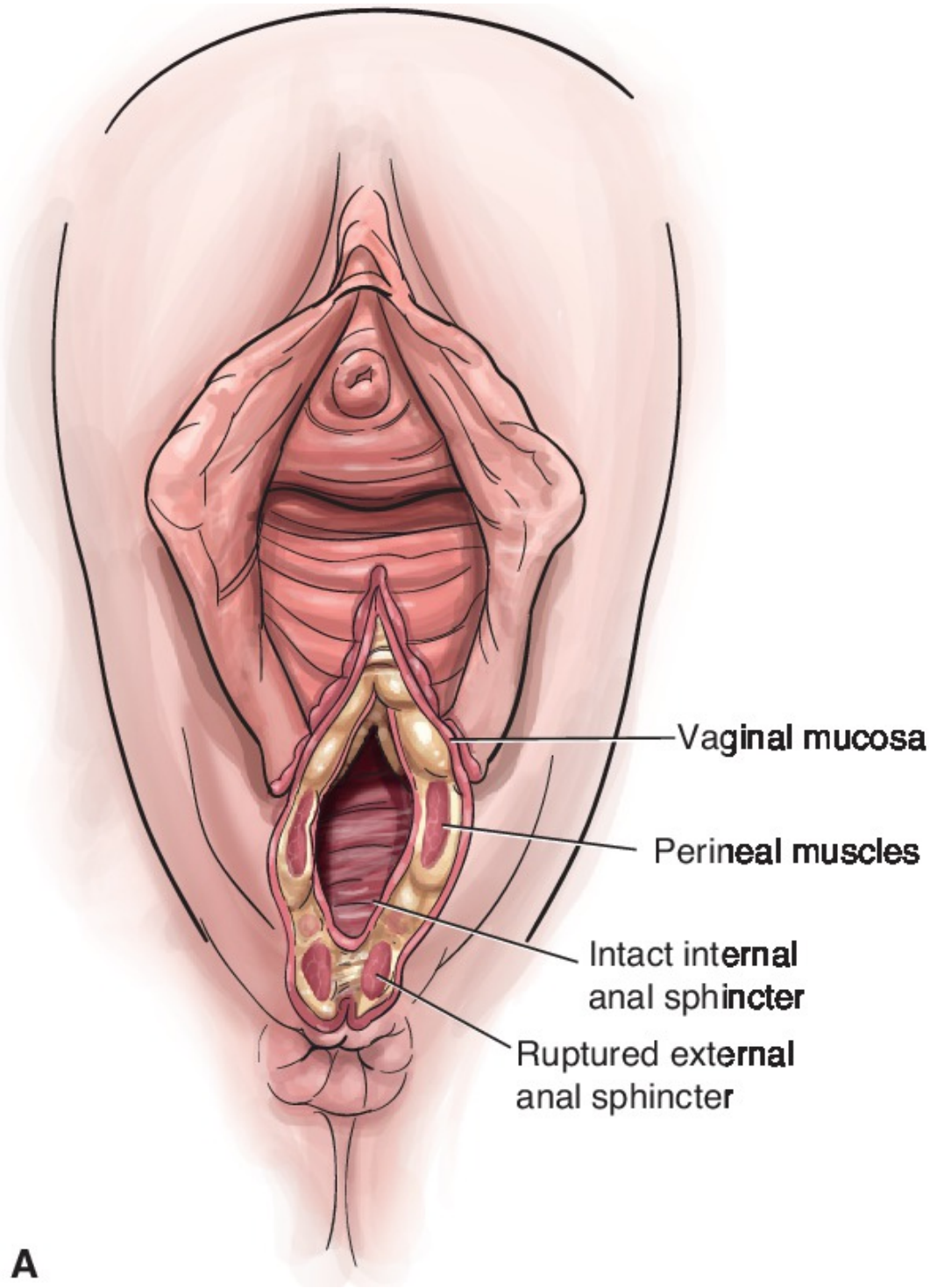
# Incidence and Risk Factors

The overall incidence of obstetric anal sphincter injuries (OASIS) after delivery is variable in the literature. However, the incidence of clinically detectable OASIS is up to 7% after mediolateral episiotomy and up to 17% after midline episiotomy. In addition, there are numerous, well-defined risk factors for this complication. Some of these factors are modifiable, while others are not. In the Childbirth and Pelvic Symptoms (CAPS) prospective cohort study of 407 women with OASIS and 390 without, Fitzgerald et al. found that vacuum-assisted vaginal delivery was associated with an increased relative odds for OASIS (odds ratio 6.3), while forceps increased the odds more than 10-fold (odds ratio 13.6). In a 2014 meta-analysis of 22 cohort studies, Pergialiotis found that heavier infants (mean diff. 192.88 g [95% CI: 139.80-245.96]), epidural anesthesia (OR 1.95 [95% CI: 1.63-2.32]), Asian ethnicity (OR 2.74 [95% CI: 1.31-5.72]), persistent occiput position (OR 3.09 [95% CI: 1.81-5.29]), operative vaginal delivery (OR 5.10 [95% CI: 3.33-7.83]), and episiotomy (OR 3.82 [95% CI: 1.96-7.42]) were all significant risk factors for OASIS. Numerous other studies have similarly demonstrated that forceps-assisted vaginal deliveries, occiput posterior presentation, and midline episiotomy are all modifiable risk factors for OASIS, while nulliparity, prolonged second stage of labor, infants >4 kg, advanced maternal age, and Asian/Indian race are nonmodifiable risk factors.

Adoption of “best practices” may lead to a reduction in OASIS. In a study published in 2008, Hirsch et al. implemented various changes in practice to decrease the rate of OASIS at a large tertiary care delivery center in Illinois. Over the course of a few months, delivering physicians modified their practices to include the following: increased utilization of vacuum extraction over forceps delivery, conversion of occiput posterior to anterior positions, use of restricted mediolateral (rather than midline) episiotomies if necessary, flexion of the fetal head and maintenance of axis traction, early disarticulation of forceps, and reduction of maternal effort at expulsion. In the 9 months following implementation of these practice changes, overall rates of OASIS decreased significantly, while neonatal outcomes did not change.

# Technique of Primary Repair

Once an OASIS is recognized, it is imperative to identify the full extent of the injury. Classification of perineal trauma has now been standardized and adopted both nationally and internationally. This classification defines a first-degree laceration as involving only the vaginal epithelium or perineal skin. A second-degree second-degree laceration is one that involves the perineal muscles but not the anal sphincter. Third-degree lacerations are further subdivided into 3a, 3b, and 3c tears. In a 3a tear, <50% of the thickness of the external sphincter is torn, while in 3b tears, >50% of the thickness of the external sphincter is torn (**FIG. 36.3A**). In a 3c tear, the internal anal sphincter (IAS) is also torn. A fourth-degree laceration involves any third-degree laceration as well as disruption of the anal epithelium (**FIG. 36.3B**).


Vaginal mucosa
Perineal muscles
Intact internal anal sphincter
Ruptured external anal sphincter
A

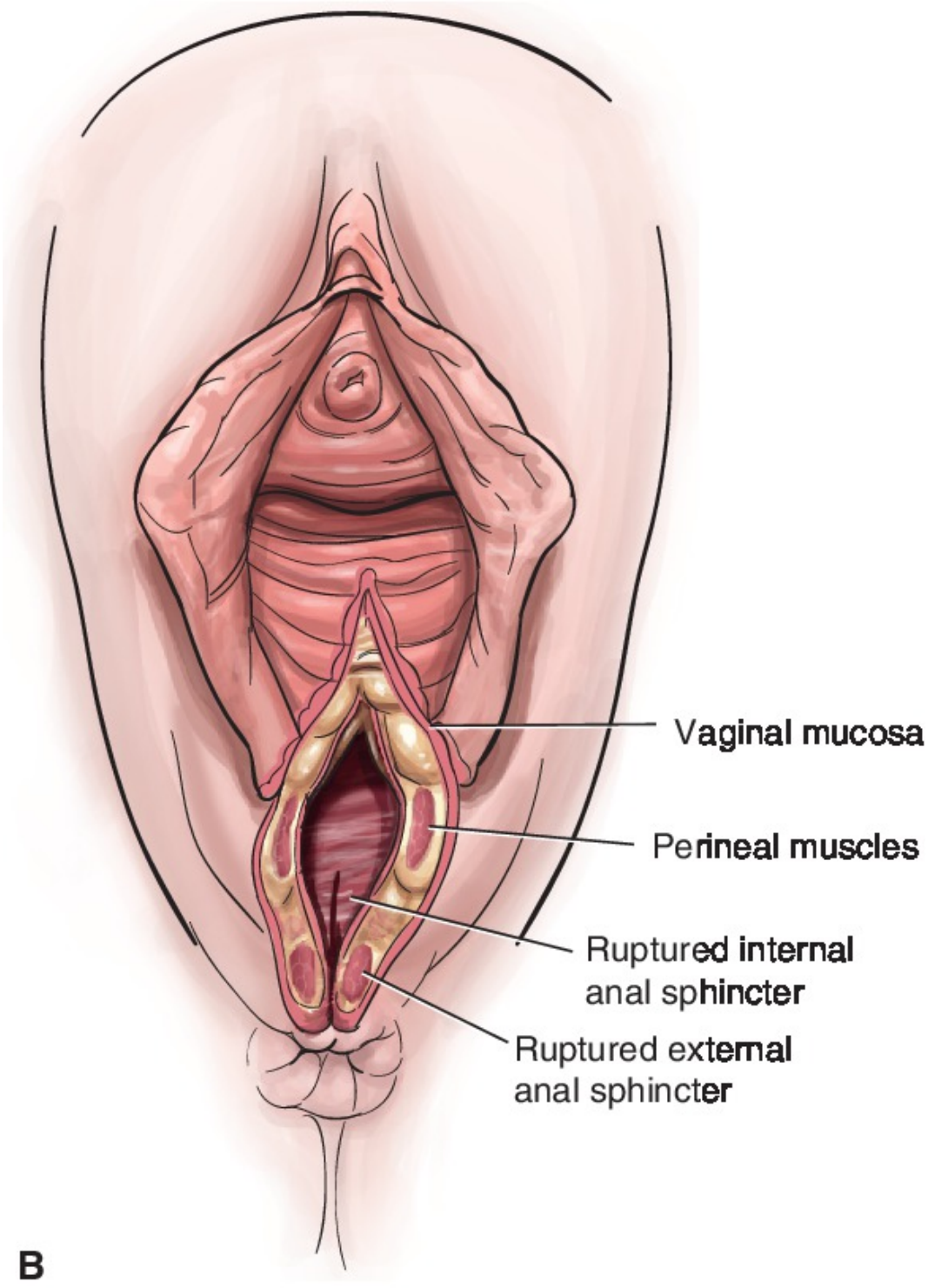



**FIGURE 36.3** **A.** Third-degree laceration. As >50% of the external anal sphincter has been disrupted, but the internal sphincter remains

intact, this is a 3b laceration. **B.** Fourth-degree laceration. The external anal sphincter, internal anal sphincter, and rectal mucosa are torn.

Once a tear has occurred, rectal examination is of paramount importance, as is identification of all structures involved in the OASIS. The optimal surgical environment for this evaluation includes good lighting, sterile and appropriate surgical equipment, good maternal pain control, and experienced physicians. The patient should be positioned appropriately in dorsal lithotomy position with stirrups. Oftentimes, this can be achieved in the delivery room; however, if it cannot be achieved there, the patient should be moved to an operating room.

If the laceration is a fourth degree, the rectal mucosa should be identified and repaired first. For this part of the repair, we recommend use of an absorbable monofilament suture (2-0 or 3-0 Monocryl); generally, the mucosa should be repaired in a continuous fashion. Next, while it can be difficult to identify in some cases, care should be taken to find and repair the IAS. The IAS is a continuation of the circular smooth muscle of the bowel and ends about 6-8 mm proximal to the anal margin at the junction of the superficial and subcutaneous part of the external anal sphincter (EAS). It appears more white. Using Allis forceps to grasp the ends of the torn muscle, delayed absorbable suture such as 3-0 or 4-0 polydioxanone can be used to repair it in a continuous fashion. Repairing of the IAS is thought to be important, as it accounts for a significant percentage of resting anal pressure and is critical in continence.

Repair of the EAS is performed next. Using Allis tissue forceps again, the torn edges of the muscle must be identified and grasped. Often, the edges are retracted when the muscle is torn. The EAS is about 3-4 cm long and thicker than the IAS. Its appearance tends to be more beefy red. Once the ends of the sphincter are identified, there are two methods of primary repair: end-to-end and overlapping.

To date, there is still some debate about which of the above methods is best for repair of the EAS. Historically, the end-to-end approximation was most popular in the delivery room, while the overlapping technique continues to be the most commonly employed method for surgical treatment chronic sphincter separation in the setting of fecal incontinence later in life. In 2002, Fitzpatrick randomized 112 primiparous patients who sustained OASIS to either end-to-end or overlapping repair. At 3 months, there was no difference in perineal pain or fecal continence between the two groups. In a 2013 Cochrane review, Fernando et al. described six randomized trials comparing both techniques and including >550 patients. No difference was found between groups in perineal pain, dyspareunia, or flatal incontinence. One year after repair, a deterioration of continence was reported by fewer patients in the overlapping repair group vs the end-to-end repair group (RR 0.26 [95% CI: 0.09-0.79]); however, this was only in one trial of 41 patients, and this difference was no longer evident at 3 years. Given these findings, these two techniques can be considered equivalent.

## *End-to-End Repair* (**FIG. 36.4**)

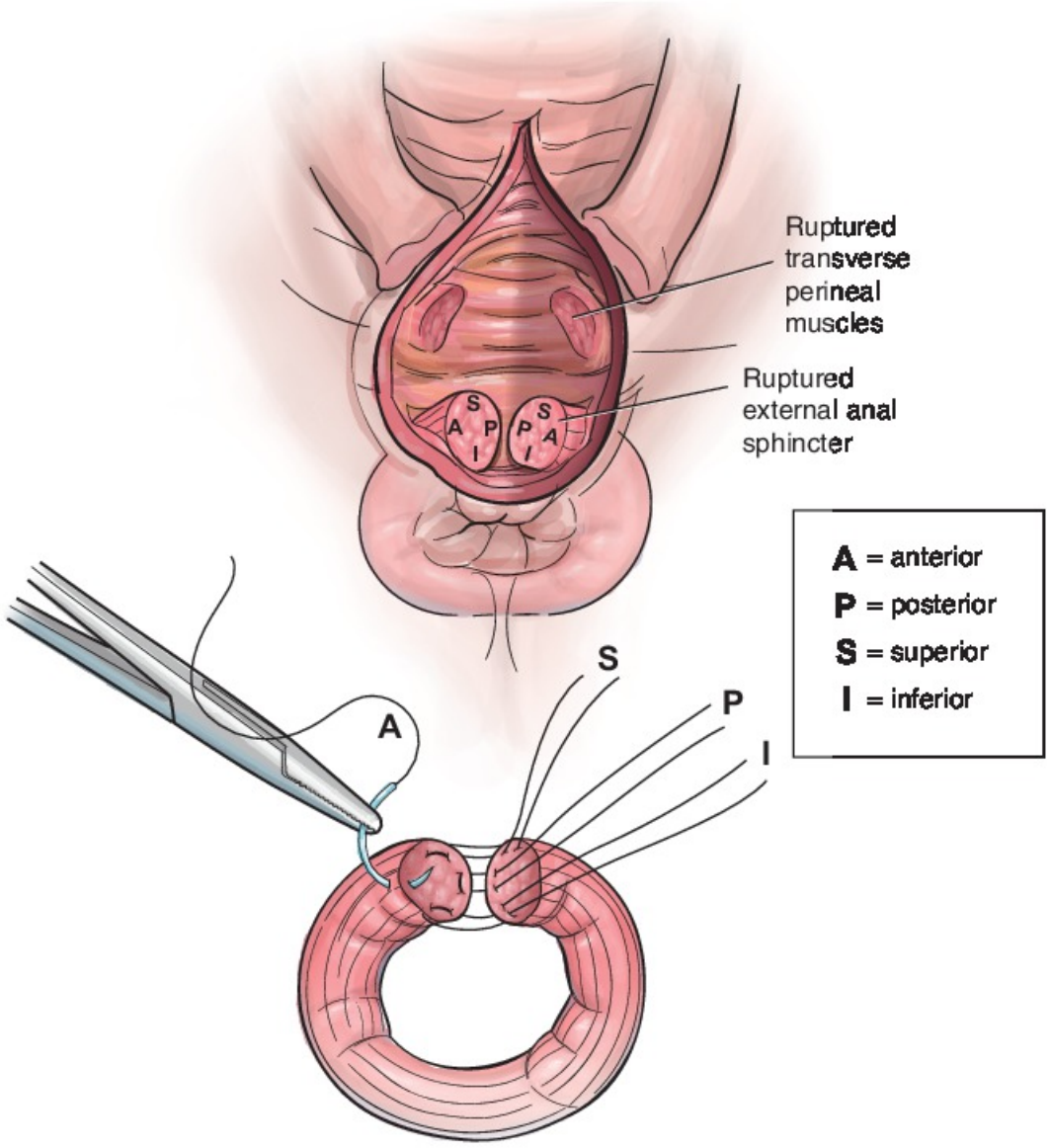



**FIGURE 36.4** End-to-end repair of external sphincter. The ends of the ruptured sphincter are grasped with Allis clamps, taking care to include the fascial sheath. The sphincter is reapproximated with three to four sutures, starting with the deep surface ("inferior"), then the posterior surface, then the superior surface, and then the anterior surface. A

delayed absorbable suture such as 2-0 polydioxanone is preferred.

This method is probably more commonly employed in the delivery room and is preferred for the repair of 3a and 3b tears. To achieve this repair, the laterally retracted sphincter ends are grasped (usually at 3 and 9 o'clock position) with Allis forceps. It is important to incorporate the fascial sheath surrounding the sphincter in the repair. Using figure-of-8 technique, the sphincter should be approximated with a delayed absorbable suture such as 2-0 polydioxanone. Delayed absorbable suture, which retains its tensile strength longer, allows for good tissue healing of the fascia and muscle. We recommend the placement of the first suture posteriorly, then inferiorly, next superiorly, and finally anteriorly (**BOX 36.2**).

## BOX 36.2 REPAIR OF A FOURTH-DEGREE LACERATION

- Identify the apex of the rectal mucosal tear. This can be closed with an absorbable monofilament suture (2-0 or 3-0 Monocryl) in a continuous fashion, going through and through the mucosa.
- Identify the internal anal sphincter, and using Allis forceps to grasp the ends of the torn muscle, delayed absorbable suture such as 3-0 or 4-0 polydioxanone should be used to repair it in a continuous fashion.
- Using Allis tissue forceps again, the torn edges of the external anal sphincter should be identified and grasped, usually at 3 and 9 o'clock positions.
- Using a figure-of-8 technique, the sphincter should be approximated with a delayed absorbable suture such as 2-0 polydioxanone. The first suture should be placed posteriorly, then inferiorly, next superiorly, and finally anteriorly.

# *Overlapping Repair*

This technique can be utilized if the entire sphincter is compromised (ie, 3c or fourth-degree OASIS). Once the ends of the sphincter are identified and grasped with Allis forceps, the muscle is mobilized laterally, using sharp dissection. Mobilization of the muscle from the ischiorectal fat should allow for at least 2 cm of overlap of the two ends of the sphincter. Similar to the end-to-end repair, 2-0 polydioxanone sutures should be used to reapproximate the sphincter in a “vest over pants” fashion. Three or four mattress sutures should be placed, reapproximating both the deep and superficial edges of the muscles (**FIG. 36.5**).

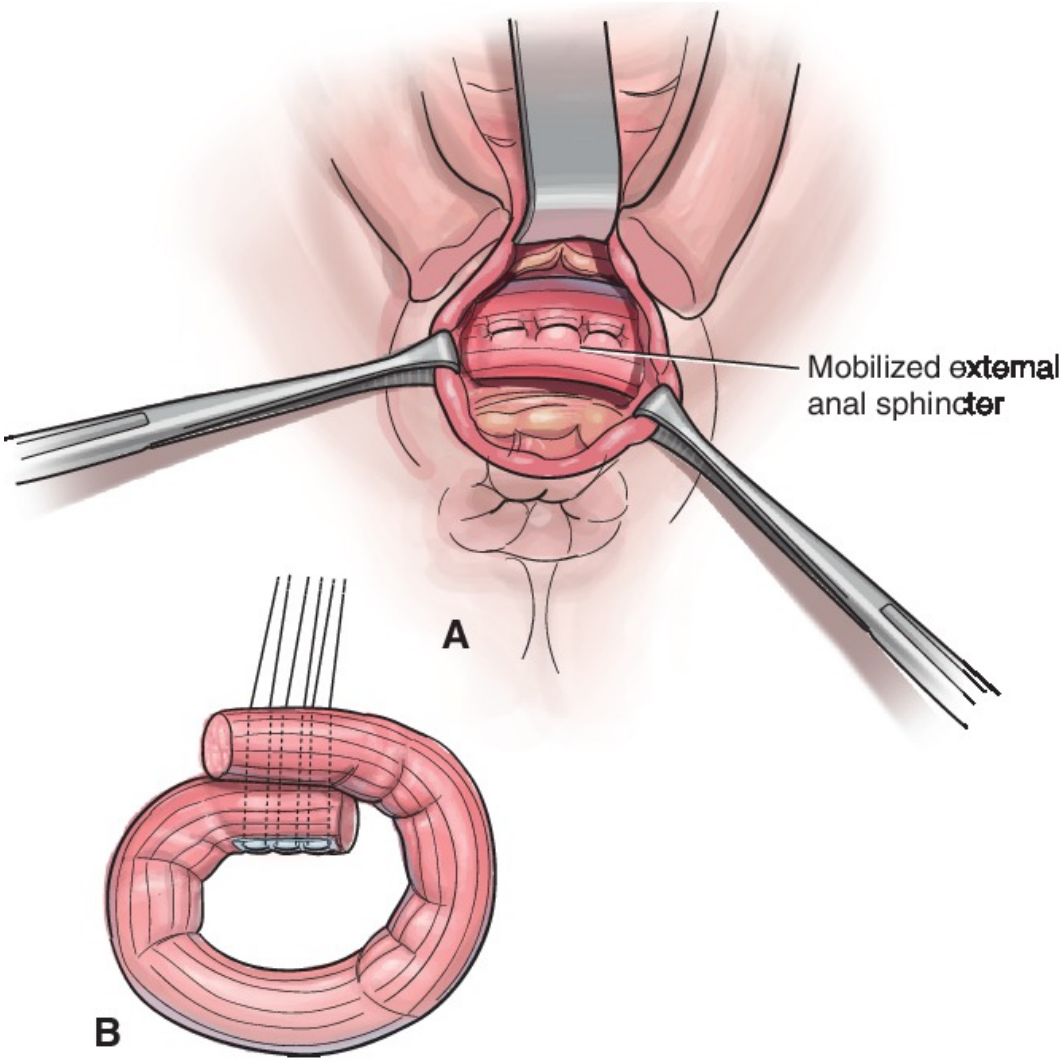


**FIGURE 36.5** Overlapping repair of external anal sphincter. For 3c or fourth-degree lacerations, an overlapping repair can be performed. The ends of the sphincter are grasped with Allis forceps, the muscle mobilized laterally using sharp dissection, to allow at least 2 cm of overlap of the two ends of the sphincter. 2-0 polydioxanone sutures should be used to reapproximate the sphincter in a "vest over pants" fashion—pulling one end over the other prior to suturing. Three or four mattress sutures should be placed, reapproximating both deep and superficial edges of the sphincter.

## Postpartum Management of OASIS

Irrespective of which method is used to repair the EAS, once the sphincter is together, the remainder of the repair should proceed as described above in the repair of a primary episiotomy. Copious irrigation of the wound is recommended to decrease bacterial load.

### *Antibiotics*

To date, there is only one randomized trial looking at the efficacy of antibiotics at the time of OASIS repair in decreasing wound infection. However, both intraoperative and postoperative antibiotics are more commonly recommended and prescribed, as it is well known that these tears are more prone to infectious complications (see below). Most experts recommend administration of an intravenous cephalosporin at the time of repair and may prescribe oral metronidazole and amoxicillin-clavulanate for 5-7 days after.

## *Perineal Care*

While there are no evidence-based guidelines for good perineal care after OASIS, twice-daily baths with perineal immersion in warm water can be beneficial not only for pain management but also to keep the area clean and facilitate healing. We generally recommend immersion for 10-15 minutes each time, with good drying techniques afterward. If a bath is not easily accessible, use of a handheld shower can be helpful as well. Use of a peri-bottle after bowel movements is recommended.

## *Follow-up*

An increasingly common practice is to schedule patients who sustain OASIS for a follow-up visit soon after the time of delivery, rather than waiting until 6 weeks postpartum. In some settings, a dedicated perineal clinic can provide added resources, including diagnostic procedures (endoanal ultrasound, manometry) as well as pelvic floor physiotherapy. Patients may benefit from specialized care after OASIS, as they are at risk for complications.

# Complications of OASIS

## *Infection and Wound Breakdown*

In a recently published prospective study of over 260 patients with OASIS, 20% were diagnosed with a wound infection within 2 weeks of delivery and 25% had wound breakdown. In this population, operative vaginal delivery increased the risk of wound complications (OR 2.54 [95% CI: 1.32-4.87]), while intrapartum antibiotics were protective (OR 0.5 [95% CI: 0.27-0.94]).

## *Fecal Incontinence*

Rates of anal and fecal incontinence after OASIS are variable; however, they are not insignificant. After OASIS, patients are at increased risk for incontinence of stool, incontinence of flatus, and fecal urgency. Anal incontinence (loss of flatus and/or stool) is more

common than fecal incontinence (**TABLE 36.1**) and may result in more symptom-specific distress and negative impact on quality of life.

## TABLE 36.1
## Anal Incontinence After OASIS

| AUTHOR | YEAR | N | FOLLOW-UP | *AI* | *FI* |
|---|---|---|---|---|---|
| Dave | 2016 | 178 | 3 mo | 59% | 15% |
| Richter | 2015 | 442 | 6 mo | 25% | 9% |
| Pollack | 2004 | 242 | 5 y | 54% | 4% |
| Fenner | 2003 | 165 | 9 mo | 30% | |
| DeLeeuw | 2001 | 125 | 14 y | 31% | |
| Nygaard | 1997 | 29 | 30 y | 59% | 28% |

AI mean ≈ 35%; FI mean ≈ 10%.AI, anal incontinence; FI, fecal incontinence.

# *Rectovaginal Fistula*

Rectovaginal fistula is a potentially devastating consequence of OASIS. While the most common cause of rectovaginal fistulas in the developed world is obstetrical trauma, fortunately, it remains rare. The incidence of fistula after fourth-degree laceration is 0.4%-3%. It is likely that many fistulas result from either failure to recognize the full extent of the original injury at the time of delivery or complications such as wound infection, hematoma formation, and breakdown in the postpartum period. The repair of a rectovaginal fistula should be undertaken only by a surgeon with expertise in this procedure. An example of fistula repair is demonstrated in **VIDEO 36.1**.

# Delayed Repair of OASIS

In the past, breakdown of OASIS repair was managed conservatively for several months, postponing surgical repair while the tissue healed and inflammation subsided. However, delayed repair is associated with significant maternal health consequences such as pain, fecal incontinence, and sexual dysfunction. Therefore, current practice emphasizes early repair if no infection is present. However, before attempting closure, it is important to prepare the wound for

repair. In our experience, wound debridement can be accomplished successfully in the office setting, with removal of all necrotic tissue and suture, followed by packing and removal with an iodoform gauze twice daily and aggressive perineal care with sitz baths. Broad-spectrum antibiotics should be utilized if the wound is infected. Once the wound is free of exudate and infection, secondary repair can be attempted. While mechanical bowel prep can be utilized preoperatively, there is a dearth of data regarding its necessity in this case. Once in the operating room, repair is done in the above-described standard fashion. In this setting, either an overlapping or end-to-end technique can be used, depending on physician experience. It is imperative that all tissues be mobilized enough to allow for a tension-free repair. Postoperatively, stool softeners can be used to keep stools soft. However, diarrhea should be avoided. Routine use of oral antibiotics is not supported by evidence-based studies, but we recommend intravenous cephalosporin at the time of repair and 5-7 days of postoperative oral metronidazole and amoxicillin-clavulanate. In several published case series, repair of OASIS wound breakdown typically occurred within 2 weeks of the initial repair, although the vast majority of patients recovered well. Of note, in a more recent study by Lewicky-Gaupp and colleagues, the majority of patients with OASIS breakdown opted for conservative management and healing of the wound by secondary intention with aggressive perineal care (twice-daily baths and wound packing changes). While longer-term outcomes of these patients are not yet published, early results are encouraging.

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# SECTION VII

# Complications of Pelvic Surgery


## 37 Management of Intraoperative Complications to the Urinary Tract
E. James Wright

## 38 Management of Operative Complications to the Gastrointestinal Tract
Mitchel Hoffman and Emmanuel E. Zervos

## 39 Management of Surgical Hemorrhage
Emma Rossi

# CHAPTER 37

# MANAGEMENT OF INTRAOPERATIVE COMPLICATIONS TO THE URINARY TRACT

E. James Wright

**Functional Anatomy of the Ureter, Bladder, and Urethra**
Ureter
Bladder
Urethra
**Injury to the Ureter in Gynecologic Surgery**
Hysterectomy
Adnexal Surgery
Retropubic Surgery
Surgery for Vaginal Prolapse
Radical Pelvic Surgery
**Diagnosing Ureteral Injury**
Diagnosis of Intraoperative Ureteral Injury
Postoperative Diagnosis of Ureteral Injury
**Techniques for Ureteral Repair**
Acute Ureteral Injury

Ureteroneocystostomy

Psoas Hitch

Boari Flap

Ureteral-Ileal Interposition

**Injury to the Bladder During Gynecologic Surgery**

Hysterectomy

Retropubic Colposuspension

Surgery for Prolapse Repair

Sling Surgery

Postoperative Diagnosis of Bladder Injury

**Injury to the Urethra During Gynecologic Surgery**

Urinary tract injuries have been recognized as a potential complication of gynecologic surgery since the inception of our discipline. Over the years, numerous unique surgical modifications of procedures have been offered with the specific intent of decreasing the probability of such injuries. Despite these efforts, the risk of unintended damage to the ureter, bladder, and urethra remains, and abdominal-pelvic surgeons must maintain vigilance to avoid these events and be familiar with identification and repair strategies to manage them effectively.

The incidence of injury to the urinary tract during gynecologic surgery is commonly cited as 1%-2%, although the incidence varies with the surgical approach, the skill of the surgeon, and the complexity of the patient's anatomy. Benson and colleagues reported injury to the urinary tract in 1.45% of 516 314 hysterectomies performed in New York State for benign indications. The vaginal approach was associated with less risk than abdominal or minimally invasive approaches. It is important for the gynecologic surgeon to be cognizant of ways to minimize the occurrence of these potential complications, as well as facile in the diagnosis and management of such injuries should they occur. Bladder injury is possible during

pelvic surgery and current analyses find this to be three times more likely than ureteral injury. The method of pelvic surgery may impact the likelihood of lower urinary tract injury, with laparoscopic- and robot-assisted procedures incurring similar risk.

The goals of this chapter are to (1) outline the functional anatomy of the ureter, bladder, and urethra and illustrate areas of increased risk for injury during gynecologic surgery; (2) review the unique issues surrounding ureteral, bladder, and urethral injury during the performance of specific groups of gynecologic surgical procedures; and (3) summarize the basic principles of injury avoidance and, should injury occur, recognition and management.

# FUNCTIONAL ANATOMY OF THE URETER, BLADDER, AND URETHRA

## Ureter

When viewed in cross section, the ureter can be divided into distinct layers: the lumen with transitional epithelium; the mucosa—the muscular layer—which is made up of longitudinal, circular, and spiral smooth muscle fibers; and the adventitia, which contains an intercommunicating network of blood vessels **(FIG. 37.1**). The peritoneum covers the ureter, making it a completely retroperitoneal structure.

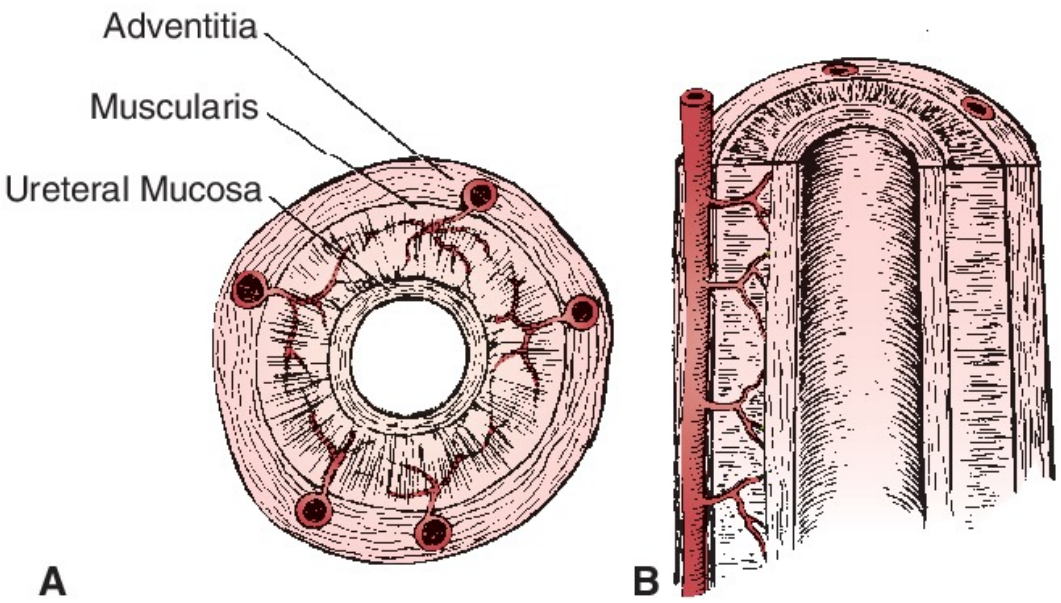



**FIGURE 37.1** Cross-sectional **(A)** and sagittal **(B)** views of the longitudinal arteries and veins in the adventitia. These arteries and veins provide the important collateral circulation along the course of the ureter.

In normal adults, the ureter is between 25 and 30 cm in length from the renal pelvis to the trigone of the bladder. By convention, the pelvic brim divides the ureter into the abdominal and pelvic segments; each of these components is ~12-15 cm in length.

The abdominal ureter runs along the ventral surface of the psoas muscle and posterior to the ovarian vessels to the level of the pelvic brim. The right ureter lies slightly lateral to the inferior vena cava and descends into the pelvis over the common iliac artery at approximately the site of the bifurcation of this vessel. In rare instances, the right ureter can be found coursing on top of the vena cava, and if one is performing a paraaortic node sampling, the ureter must be identified before removing any tissue. The left ureter runs lateral to the aorta and posterior to the inferior mesenteric artery, ovarian vessels, and sigmoid colon. The left ureter mirrors the right at the pelvic brim, entering the pelvis over the bifurcation of the left

common iliac artery (**FIG. 37.2**). The left ureter is commonly obscured by the sigmoid colon at the pelvic brim.

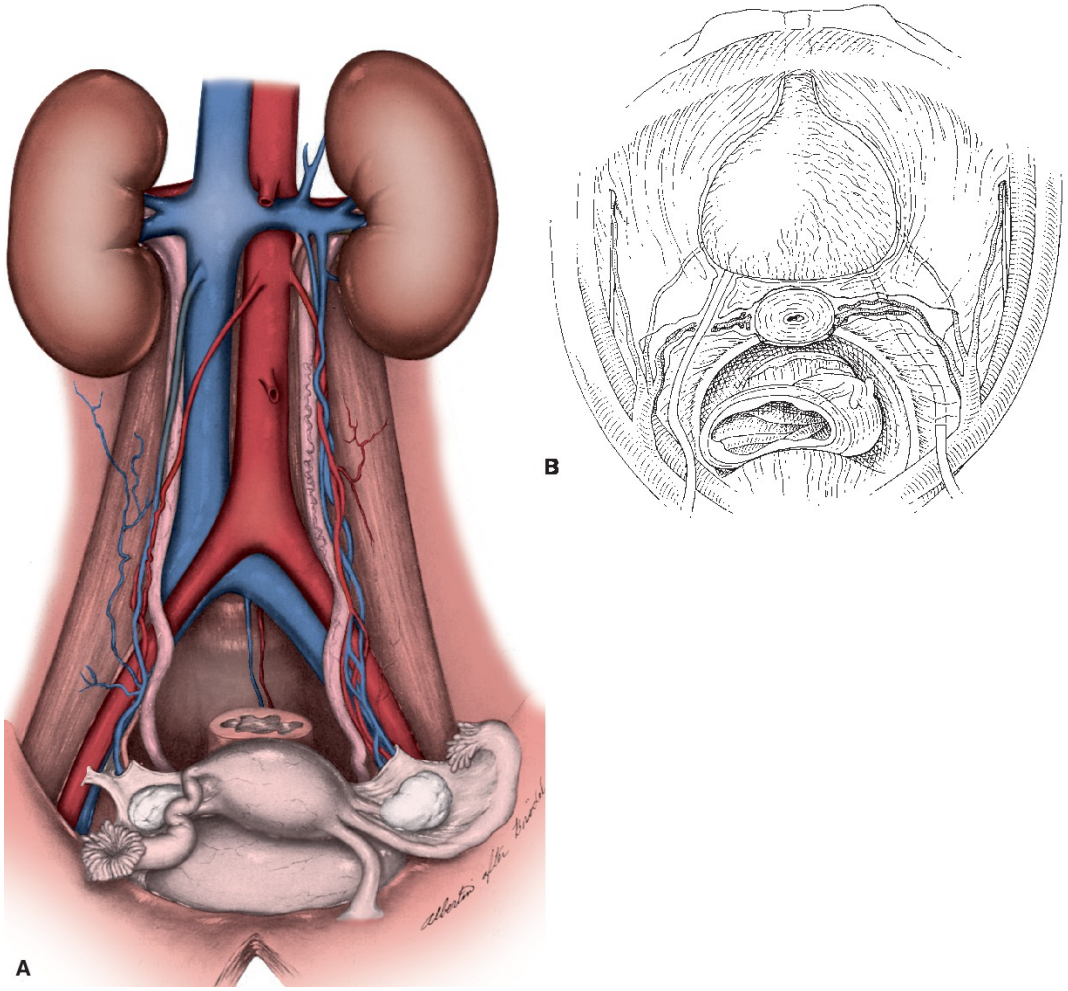



**FIGURE 37.2** **A.** Abdominal and pelvic portions of the ureter showing relation to aorta, psoas muscle, vena cava, and common iliac artery and vein. **B.** Pelvic portion of the ureter showing its course along the sidewall of the pelvis and its relation to the common iliac vessels, hypogastric vessels, uterosacral ligaments, uterine vessels, and cervix.

There is little variance between the positions taken by the pelvic ureters. They descend into the posterior lateral pelvis lateral to the sacrum and immediately ventral to the internal iliac (hypogastric) artery. The ureters then course medial to the internal iliac artery and its anterior branches and subsequently pass beneath the uterine artery (often referred to as *water under the bridge*). The ureter is ~1.5 cm lateral to the cervix where it enters the paracervical tissues and cardinal ligament/anterior bladder pillar (also referred to as the web or the tunnel of Wertheim). Once through this tunnel, the ureter travels medially and anteriorly over the vaginal fornix to enter the trigone of the bladder.

When inflammatory or adhesive change is absent, the ureters can usually be visualized through the peritoneum from the pelvic brim to the parametrial tissue. Once the ureters have entered the "tunnel," they cannot be easily seen or palpated; if identification is required, they must be dissected free of this tissue. Although the peristaltic activity that occurs in the normal ureter may be helpful in its identification, it is not uncommon that the ureter following any degree of trauma will have transient paralysis. Accurate identification of the ureter is, therefore, based on understanding its anatomy, not its motion. The ureter is unique in that it has a "snap" feeling when passed between the fingers during laparotomy. This may be helpful in obese women with difficult exposure. This "snap" will also permit one to follow the ureter to the tunnel without actually exposing it. This technique is not applicable to laparoscopic or robot-assisted procedures. In these cases, identification of the ureter is enhanced by camera magnification but may require determined surgical exposure for confirmation of its course. Having defined the general anatomy of the ureter, one must appreciate the significant interpatient variability, even in a pelvis free of inflammatory, infectious, neoplastic, congenital, or postsurgical changes. Direct visualization of the ureter is the only sure way to know its location in any given patient.

Along its course, the vascular supply of the ureter is derived from a variety of sources. Above the pelvic brim, the blood supply of the ureter is derived from medial vessels; more distally, the blood supply originates laterally (**FIG. 37.3**). Cephalad to the pelvic brim,

dissection and mobilization of the ureter should be approached from its lateral aspect with the converse true distal to the pelvic brim. The ureter is perfused by a rich vascular network, with anastomoses within the adventitial sheath. The ureter is, therefore, relatively resistant to devascularization. However, ischemic injury may occur and can be difficult to diagnose, as the sequelae may not be apparent until the postoperative period.

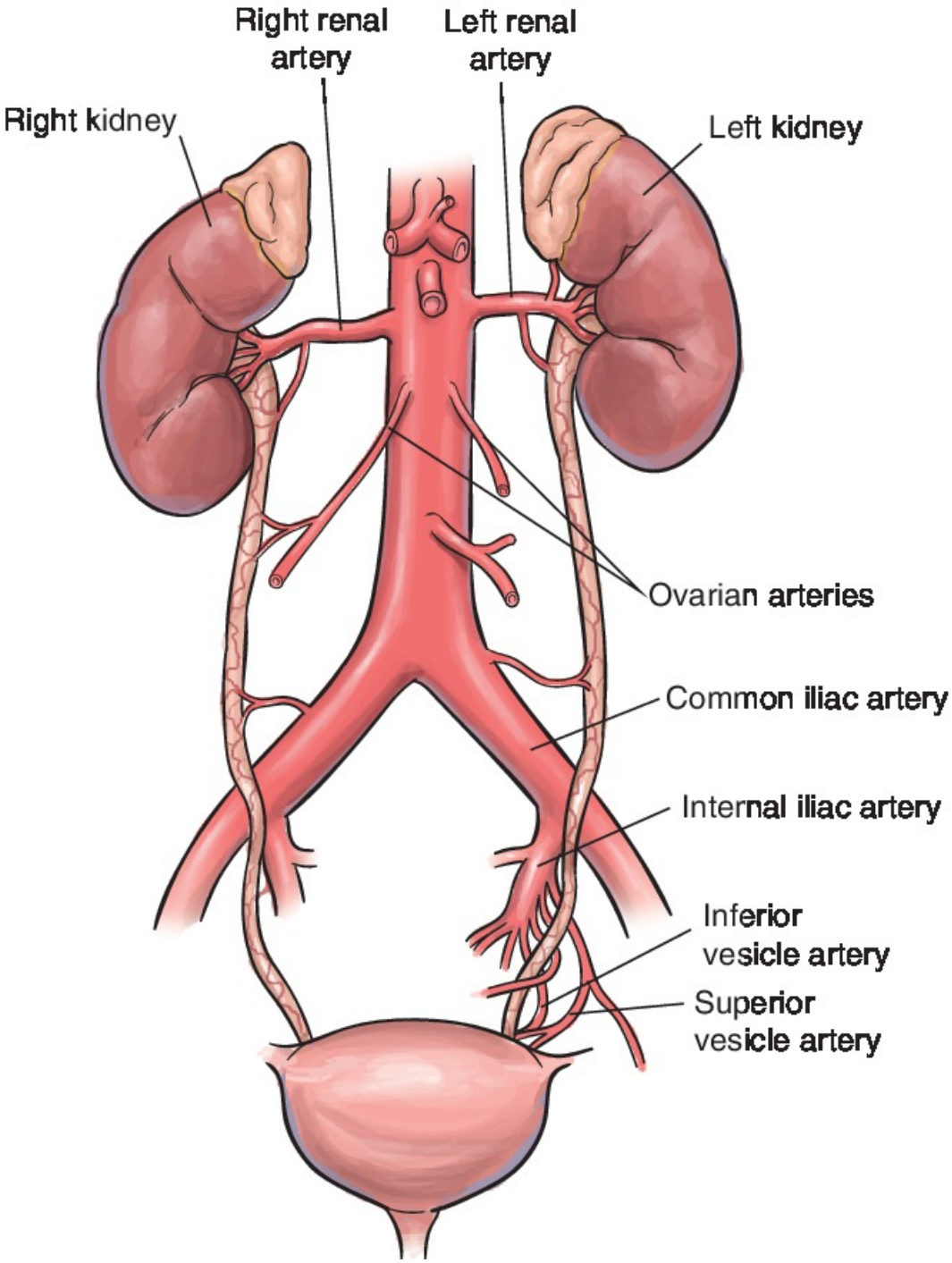



**FIGURE 37.3** Blood supply of the ureter.

## Bladder

The urinary bladder is comprised of a unique internal epithelium, a smooth muscle syncytium, and a fibrofatty serosal outer layer. It is confined to the pelvis when decompressed but tethered to the umbilicus by the urachus and moves into the abdomen with increasing distention. While occupying a preperitoneal position, the posterior aspect of the bladder dome is accessible from the abdomen. The base of the bladder rests on the anterior vagina, which is supported by the vaginal attachments to the arcus tendineus fascia pelvis from the ischial spine to the pubic ramus. While the bladder floor and anterior vaginal wall are separable, the fusion plane between these structures can sometimes be densely adherent.

The vascular supply to the bladder derives primarily from the internal iliac (hypogastric) artery via the superior and middle vesical arteries. Arborization of these vessels allows for redundancy and low risk of devascularization with pedicle ligation.

The bladder neck and proximal urethra are located beneath the symphysis, with the dorsal artery and vein located on their anterior surface. An additional rich network of veins can be found lateral to the bladder neck along the anterior surface of the vagina.

These vascular and structural characteristics place the bladder at risk for injury during pelvic surgery performed both abdominally and vaginally but so too provide great flexibility for repair and reconstruction.

# Urethra

The female urethra traverses the underside of the symphysis pubis, anchored by the urethropelvic ligaments and periurethral elements of the levator ani and pelvic floor musculature. It is made up of a distinct epithelial lining wrapped in a pliable vascular coat (corpus spongiosum). The urethral continence mechanism is thought to be localized to the proximal 2/3 and relies on both the periurethral support structures as well as the viscoelastic properties of the epithelium. The urethra is not easily accessible from the abdominal approach but can be easily manipulated during vaginal surgery.

# INJURY TO THE URETER IN GYNECOLOGIC SURGERY

## Hysterectomy

The ureter is vulnerable to injury during hysterectomy when the uterine artery is divided (**FIG. 37.4**). This is because the ureter passes under the uterine artery, lateral to the uterosacral ligaments, as it travels medially and ventrally to terminate in the bladder. The risk of injury to the ureter can be minimized by careful dissection of the bladder off the cervix, by upward traction on the uterus during the placement of clamps, and by clamping the uterine artery immediately along the cervix (rather than more laterally). At the conclusion of hysterectomy, the surgeon should be particularly vigilant when addressing bleeding from pedicles, especially at the vaginal angles. Bleeding from the pedicles or vaginal angle should be controlled by a “superficial” 3-0 suture so as not to incorporate the ureter.

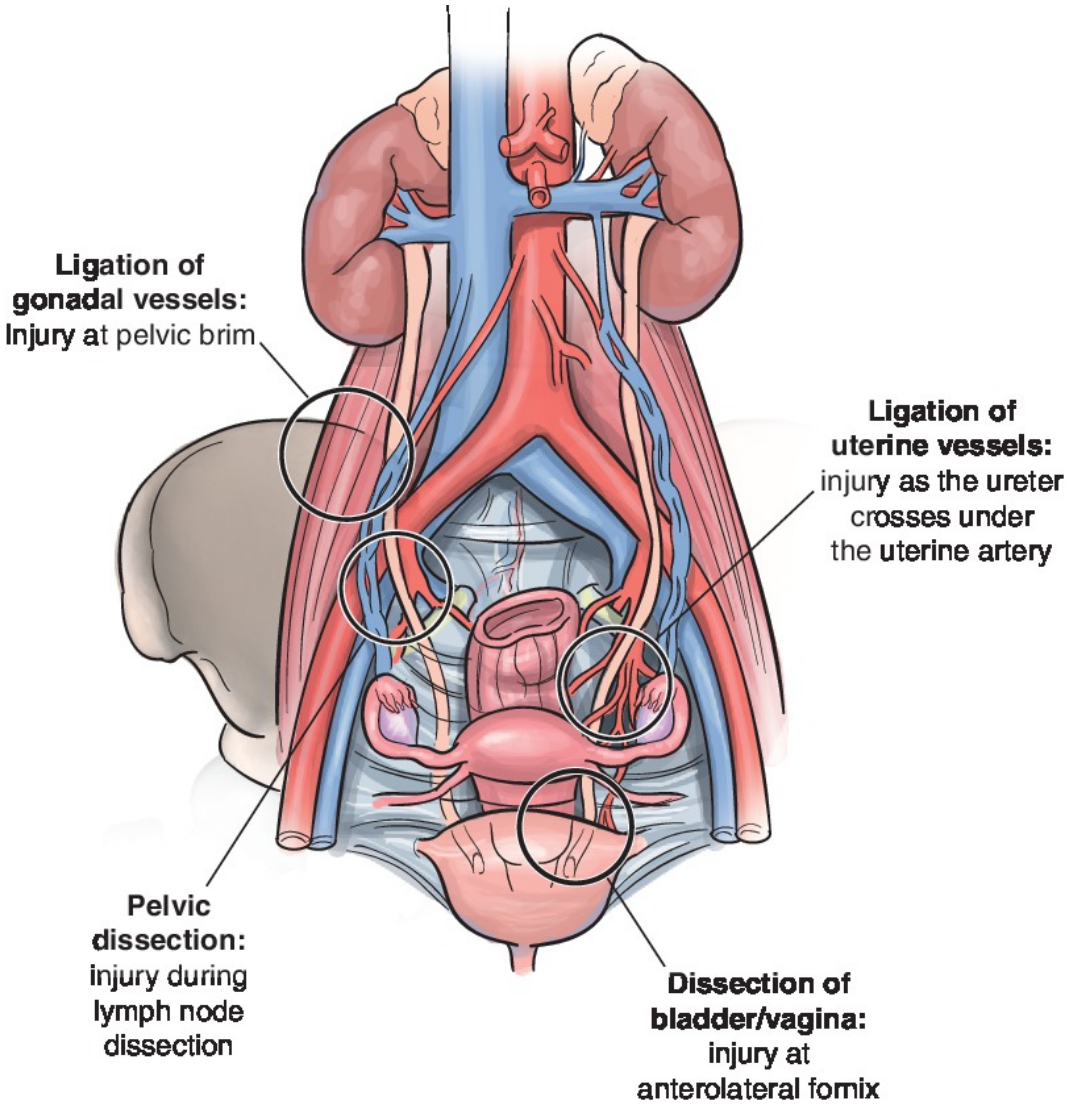



**FIGURE 37.4** Site of potential ureteral injury near uterine vessels.

Hysterectomy in the setting of cervical or broad ligament fibroids can be particularly challenging. The ureter can be anterior, lateral, or posterior to the fibroid. Clamping pedicles around the fibroid imposes significant risk for ureteral injury. In such cases, it may be prudent to perform a myomectomy by incision adjacent to the uterus or cervix. This can be done without risk of ureteral injury by staying within the myometrial capsule of the fibroid. Bleeding may occur, but once the fibroid is removed, such bleeding can be more easily controlled. In

the rare case when this is impossible, the entire course of the ureter should be identified before clamping or cutting.

Ureteral injury during vaginal hysterectomy is relatively uncommon. To some extent, this may be due to case selection, as vaginal hysterectomy is not typically performed for conditions most likely to distort ureteral anatomy, such as endometriosis or malignancy. In addition, the risk of ureteral injury is reduced during vaginal hysterectomy (compared to abdominal hysterectomy) because traction on the cervix pulls the uterus farther from the ureter. Tension on the cervix is, therefore, critical during the clamping of pedicles.

Ureteral injuries that occur during laparoscopic hysterectomy may be the result of thermal injury. When performing laparoscopic hysterectomy, it is imperative to know the location and course of the ureter. It can usually be visualized through the peritoneum; when not visible, it should be identified retroperitoneally and followed to the site of operative interest. Extreme caution should be used with cautery near or over the ureter, as thermal spread can cause occult injury that may not become apparent until 5-10 days after surgery.

# Adnexal Surgery

Ureteral injury at the time of adnexectomy is worthy of specific comment. Especially in cases of an adnexal mass and distortion of the anatomy, the ureter is particularly vulnerable, and it is in this setting that the ureter is commonly injured.

These injuries may be avoided by using a retroperitoneal approach.

The pelvic surgeon must be able to quickly and safely enter the retroperitoneum (which continues deep into the pelvis as the pararectal space). This surgical skill is necessary to (1) access the pelvic vessels for the purpose of establishing hemostasis and (2) use the retroperitoneum as an adhesion- and pathology-free “space” in which to operate. Access is obtained most commonly for the latter purpose. Once this retroperitoneal space has been developed, the ureter should be visible on the medial leaf of the broad ligament.

If an adnexal mass is adherent to the peritoneum overlying the ureter, the ureter can safely be dissected from the peritoneum. Distal to the pelvic brim, the dissection should be approached from the medial aspect of the ureter to minimize the risk of ischemia. Once the ureter has been mobilized, resection of the mass and the inflamed, scarred, or fibrotic peritoneum can be completed safely (**FIG. 37.5**). There are rare instances when it is impossible to mobilize the ureter from the pathology. In this setting, the surgeon must decide whether to leave residual tissue on the ureter (risking subsequent ureteral obstruction) or to resect a segment of ureter and repair accordingly.

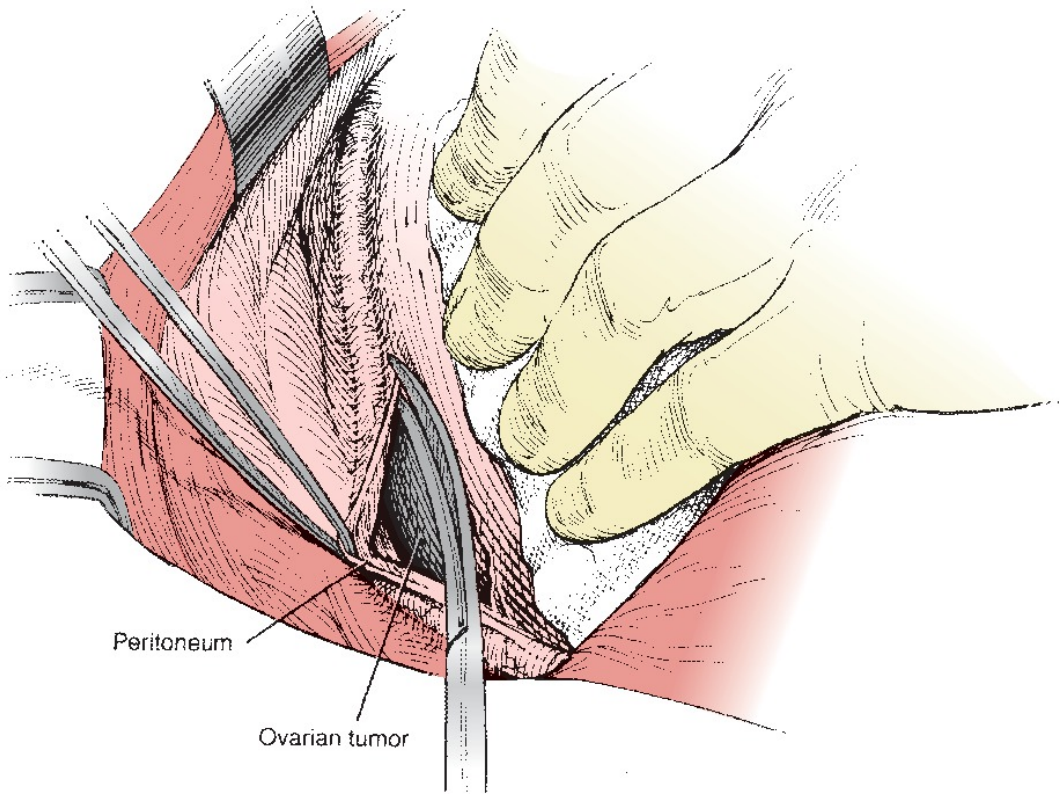



**FIGURE 37.5** The ureter is dissected away from the peritoneum to permit resection of ovarian mass/remnant.

# Retropubic Surgery

Injury to the distal ureter may occur with high elevation of Burch colposuspension sutures. The ureter may also be injured by excessive lateral mobilization of the bladder, which can expose the dorsal surface of the bladder in the vicinity of the trigone, bringing the ureter into the operative field.

There are specific steps that can be taken to avoid such injuries. Dissection into and through the space of Retzius should be done under direct visualization, remaining as close to the symphysis pubis as possible. The amount of dissection that occurs over the lateral paravaginal tissues should be minimized to guarantee accurate and appropriate suture placement. Finally, the urethrovesical junction must not be elevated excessively as this can cause kinking not only of the urethra but also the ureters in certain patients.

# Surgery for Vaginal Prolapse

The ureter may be inadvertently ligated or kinked with surgery to correct prolapse. The risk appears to be highest with uterosacral ligament suspension of the vagina. Barber and colleagues reported ureteral obstruction in 11% (5/46) cases of uterosacral ligament suspension. Karram reported ureteral injury in 5/202 (2.4%), and Shull reported ureteral injury in 3/302 (1%). Immediate recognition is essential, as removal and replacement of suspension sutures can avoid ureteral compromise.

Anatomic studies by Buller demonstrated that the distance from ureter to uterosacral ligament is 4.1 ± 0.6 cm at the sacral origin of the uterosacral ligament, decreasing to 0.9 ± 0.4 as the uterosacral ligament approaches the cervix. Placement of the suspension sutures at or slightly above the level of the ischial spine (in the intermediate portion of the uterosacral ligament) is, therefore, recommended to minimize the risk of injury. Ureteral injury has also been reported with sacrospinous suspension, midurethral sling, and anterior colporraphy. Thus, confirmation of ureteral patency (via cystoscopy to assess for ureteral efflux with an intravenous coloring agent, such as fluorescein, methylene blue, or intravenous indigo

carmine) should be routinely performed at the conclusion of these procedures.

## Radical Pelvic Surgery

Of all the groups of surgical procedures performed, those for the treatment of cancers affecting the female reproductive tract are most likely to involve either intentional ureteral surgery or have the highest risk of an associated ureteral injury. It is important to differentiate between intentional ureteral disruption and unintended or inadvertent injury. The MD Anderson type IV radical hysterectomy, a total or anterior pelvic exenteration, and resection of a fixed pelvic sidewall mass involving the ureter may include ureteral resection and reconstruction by design. As a result of the nature of gynecologic malignancies and the procedures performed to treat those diseases, intentional and sometimes unintentional ureteral injuries occur. Additionally, the need to explore a radiated or multiply operated field compounds cofactors that put the ureter at risk. It is evident that the radical pelvic surgeon must not only be expert in pelvic anatomy but also have the judgment to establish how and when to attack a problem while minimizing the probability of injury.

# DIAGNOSING URETERAL INJURY

## Diagnosis of Intraoperative Ureteral Injury

As noted, pelvic surgery risks injury to the ureter at a number of sites along its course (**TABLE 37.1**). A clear understanding of ureteral anatomy and its potential variability is critical to avoiding injury. The pelvic surgeon should make a habit of confirming ureteral integrity during and at the conclusion of any pelvic procedure, regardless of whether the surgery is done by the vaginal, open, laparoscopic-, or robot-assisted approach. This will require direct visualization of the ureter (or palpation, in the setting of laparotomy). For both open and laparoscopic procedures, opening of the parietal peritoneum may at

times be necessary to allow for accurate inspection or to allow for mobilization and separation from the site of operative interest. This is especially important in the setting of inflammatory conditions such as endometriosis, malignancy, or adhesions from prior surgery.

## TABLE 37.1
## Common Sites of Ureteral Injuries

| |
|---|
| Cardinal ligament where the ureter crosses under the uterine artery |
| Tunnel of Wertheim |
| Intramural portion of the ureter |
| Dorsal to the infundibulopelvic ligament near or at the pelvic brim |
| Lateral pelvic sidewall above the uterosacral ligament |

If ureteral injury is suspected, visualizing peristalsis is inadequate to exclude occlusion or extravasation. Ureteral integrity can be confirmed during intra-abdominal surgery by intravenous administration of a coloring agent such as indigo carmine and observation for intrapelvic extravasation. In vaginal surgery, direct visualization of the at-risk ureteral segments is seldom possible. Intraoperative cystoscopy can be used for confirmation of urine efflux from the ureteral orifices at the conclusion of transvaginal procedures accessing the anterior or apical vagina. This may be facilitated by an intravenous coloring agent (such as indigo carmine, fluorescein, or methylene blue). Following abdominal procedures, cystoscopy may also be performed to confirm ureteral patency. The use of a flexible cystoscope allows this procedure to be done with the patient in supine position if necessary. Studies are conflicting as to whether routine intraoperative cystoscopy is either helpful in reducing the risk of ureteral injury or cost-effective. It is generally agreed, however, that increased concern for ureteral injury should prompt cystoscopic evaluation.

Acute ureteral injuries are best recognized and managed intraoperatively. Many of these occurrences may rely on assistance from colleagues in urology or urogynecology. This would include decisions regarding the nature of the repair and the decision to proceed with intracorporeal repair vs conversion to laparotomy in the setting of laparoscopic and robot-assisted procedures. Successful intraoperative repair of ureteral injuries minimizes the risk of sequelae, including stricture, fistulae, loss of renal function, and need for subsequent reoperation.

With the common and generous use of cautery devices in pelvic surgery, ureteral injury may not be apparent until the postoperative period. Cautery devices must be used with care, as diffusion of thermal energy can cause occult ureteral injury resulting in delayed stricture or urine leak presenting days to weeks postoperatively. A high index of suspicion must be carried through the postoperative period to insure early diagnosis and management as necessary.

It is unclear whether preoperative ureteral stenting aids in preventing ureteral injury. The data generally suggest that presence of a ureteral stent facilitates identification of injury should it occur, rather than prevention of such injuries. Complications related to stent placement (including ureteral perforation, stent malposition, extravasation, hematuria, and stricture) are rare. However, preoperative stent placement is typically considered in complex cases. In this setting, stent placement can be uniquely challenging, with potential increase in the risk of complications.

# Postoperative Diagnosis of Ureteral Injury

The sequelae of unrecognized ureteral injuries commonly present in the immediate postoperative period but may develop up to several weeks following surgery. This is especially true for thermal injuries resulting in intraperitoneal or retroperitoneal urine leak (eg, urinoma) or ureteral stricture. Common manifestations of urinoma include fever, unexplained leukocytosis, peritonitis, or vaginal fluid leakage. Hematuria may also be seen. Rarely urinoma may present as a

palpable pelvic or abdominal mass. It should be noted that changes in serum creatinine are not a reliable indicator of ureteral injury. Postoperative elevations in serum creatinine should prompt further investigation, but normal values do not adequately exclude ureteral injury.

Accurate diagnosis of a delayed ureteral injury relies primarily on appropriate imaging studies, such as computed tomography with administration of intravenous contrast and delayed image acquisition. This study can delineate ureteral obstruction as well as urine extravasation. In cases presenting with unilateral flank pain postoperatively, a renal ultrasound study may be obtained initially to assess for obstruction (hydroureteronephrosis) as well as urinoma. This study may identify obstruction and urinoma but may fail to detect a urine leak.

Retrograde ureteropyelography is also useful in the diagnosis and initial therapy of a ureteral injury. Contrast injection and opacification of the ureter can define the site and severity of leakage or obstruction and facilitates possible ureteral stenting. This can allow for control and resorption of a urinoma, and in many cases spontaneous healing of the ureter. If stenting is not possible, a nephrostomy tube can be placed to facilitate urine drainage and prevent renal injury. A large urinoma may be drained percutaneously for initial management. If surgical intervention is necessary to repair a ureteral injury, this is best done within the first 3-5 days postoperatively. Beyond this window, reconstruction is optimal after 6-8 weeks to allow resolution of postsurgical inflammation.

In cases presenting with vaginal drainage, it is important to differentiate ureteral injury from bladder injury. Recognition that these injuries can occur simultaneously is important. The bladder can be filled through a catheter with dilute methylene blue and saline solution and a tampon placed in the vagina. Staining of the tampon indicates a vesicovaginal fistula. If this initial test is negative, oral phenazopyridine or an intravenous colorant (indigo carmine or methylene blue) can be administered and the test repeated. Staining of the tampon indicates a ureteral vaginal fistula. It is also possible to collect the leaking fluid and analyze its creatinine content. A value greater than the serum level is consistent with urine leak. Urine

typically has a creatinine content >10 mg/dL. Imaging studies would follow in order to localize the site of injury.

# TECHNIQUES FOR URETERAL REPAIR

Several common elements associated with ureteral injury are listed in **TABLE 37.2**. Successful management of surgical ureteral injury requires an understanding of ureteral anatomy as well as the mechanism of injury. The ureter can be divided anatomically into thirds, with the upper segment defined by the ureteropelvic junction and proximal 5 cm. High in the retroperitoneum, the upper segment is seldom injured during pelvic surgery. The mid-ureter defines the segment from below the UPJ to the pelvic brim. The lower ureter includes the segment from the pelvic brim to the ureteral orifice. Selection of repair strategy is based on the location of ureteral injury (**TABLE 37.3**).

## TABLE 37.2
## Ureteral Injury Associated With Gynecologic Surgery: "Most Commons"

| |
|---|
| Most common site: pelvic brim near the infundibulopelvic ligament |
| Most common procedure: simple abdominal hysterectomy |
| Most common type of injury: obstruction, stricture formation |
| Most common "activity" leading to injury: attempts to obtain hemostasis |
| Most common time of diagnosis: none: 50-50 split between intraoperative and postoperative |
| Most common long-term sequelae: none |

## TABLE 37.3
## General Guidelines for Management of Ureteral Injuries Identified at Time of Surgery

| |
|---|
| Ureteral ligation: release of ureter, assessment of viability, stent placement |
| Partial transection: primary repair over ureteral stent |
| Total transection<br>• Uncomplicated upper and middle thirds: ureteroureterostomy over ureteral stent<br>• Complicated upper and middle thirds: ureteroileal interposition<br>• Lower third: ureteroneocystostomy with psoas hitch over ureteral stent |
| Thermal injury: resection with management as per a transection |

# Acute Ureteral Injury

The ureter may be injured by transection, ligation, or thermal conduction. In cases where the ureter is partially transected, it can be closed loosely with fine (5-0) absorbable suture and stented. This applies along the entire length. In such cases, placement of the stent can be accomplished over a flexible guidewire using intraoperative cystoscopy (flexible cystoscopy is useful if the patient is supine) or directly through a small anterior cystotomy. The bladder is typically drained for 7-10 days following ureteral repair.

In cases of complete ureteral transection, the level of injury guides the method of repair. General principles of ureteral repair include spatulation ≥1 cm to create a wide caliber lumen, judicious ureteral mobilization to allow for tension-free anastomosis, and use of fine absorbable suture (4-0, 5-0) to minimize inflammatory response and subsequent stricture. The ureter is typically stented at the time of reconstruction and a suction drain placed near to but not in contact with the repair. Duration of stenting is variable, but there is

little evidence to suggest a period >14 days is either necessary or helpful. The decision regarding robotic, laparoscopic, or open repair is at the discretion of the operating surgeon. The best chance of an optimal outcome should drive the decision.

In the mid-ureter, ureteroureterostomy is often the procedure of choice. The proximal and distal ends of the ureter are carefully mobilized with preservation of the adventitia and feeding blood vessels. The exposed ureteral ends should be viable with a bleeding edge. If thermal injury is suspected, the involved edges should be debrided or resected to healthy tissue. The use of intravenous indocyanine green and near infrared thermal imaging available with current robotic surgical platforms may aid in assessing ureteral viability. The ends of the ureter are spatulated for at least 1 cm to allow for a wide caliber tension-free anastomosis (**FIG. 37.6**). Fine absorbable suture should be used to minimize risk of stricture. The ureter is stented. A stent of 24-26 cm in length is usually sufficient. Stent placement is facilitated by advancing a guidewire into the proximal ureter and renal collecting system and advancing the stent over the wire. The distal end of the stent can be uncoiled, threaded into the ureter, and advanced into the bladder. Alternatively, the bladder can be opened and a guidewire passed into the ureteral orifice on the side of the injury. The anastomosis may be supported by an omental wrap if available. If transection has occurred in the lower ureter, simple ureteroneocystostomy may be performed (see section “Ureteroneocstostomy”) (**BOX 37.1**).

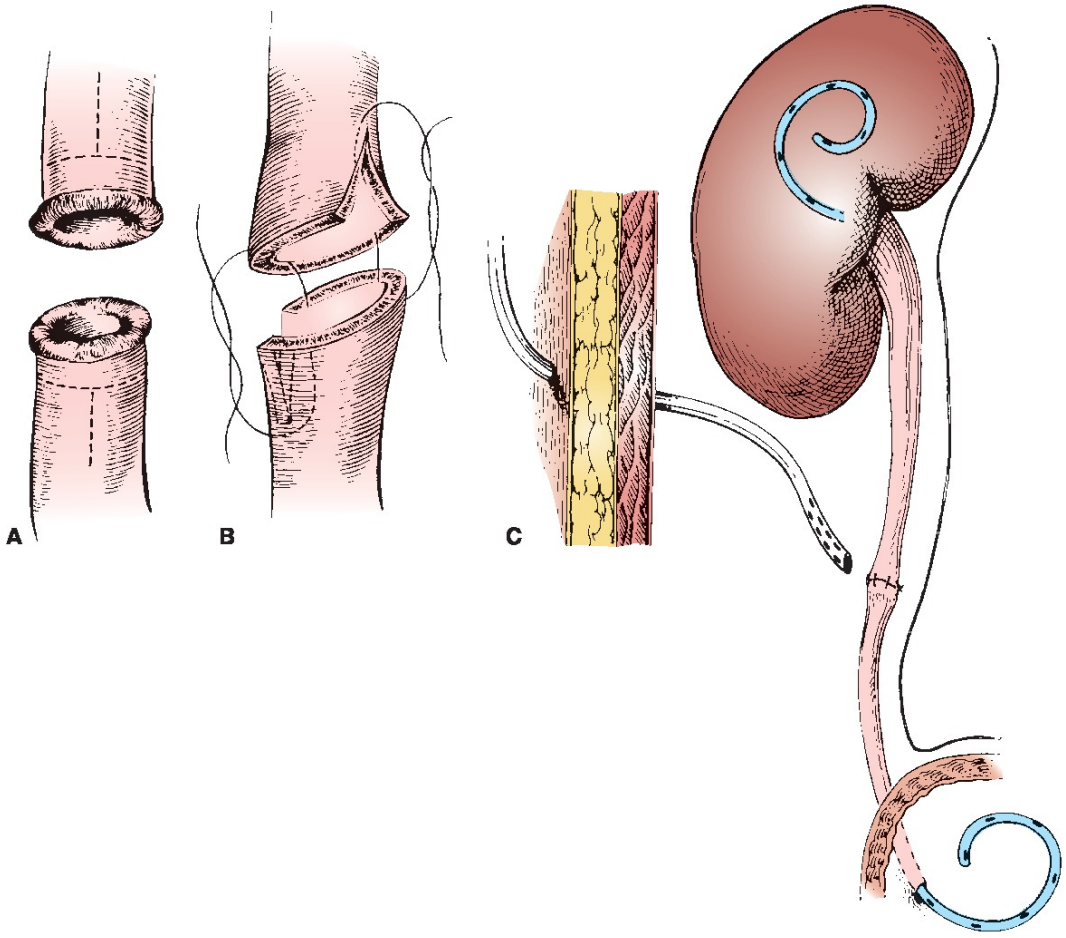



**FIGURE 37.6** Ureteroureterostomy. **A.** The ends of the ureters are trimmed obliquely and spatulated. **B.** Fine delayed absorbable sutures are used to approximate the ends of the ureter. **C.** The anastomosis is done over a double-J or pigtail stent placed after the posterior aspect is completed. A suction catheter is placed retroperitoneally at the site of anastomosis.

## BOX 37.1 STEPS IN THE PROCEDURE

## Ureteroureterostomy

- The site of ureteral injury is identified. If this is an acute injury in the mid portion (below the ureteropelvic junction and above the pelvic brim), ureteroureterostomy is a suitable option.
- The proximal and distal aspects of the ureter are dissected from the surrounding attachments sharply with care taken to preserve the periureteral sheath and periureteral blood supply.
- The exposed ureteral lumen is debrided until a healthy edge is obtained. This is essential in the setting of either a crush injury (from clip, clamp, or suture) or thermal insult and may require tissue resection.
- The proximal and distal ends of the ureter are spatulated using fine scissors for 1 cm or more to allow for an overlapping, tension-free anastomosis.
- Ureteroureterostomy is complete using fine (4-0, 5-0) absorbable suture using either a running or interrupted technique.
- Prior to completing the anastomosis, a double-J ureteral stent is placed. A stent of 24-26 cm in length is usually sufficient. This is facilitated by advancing a guidewire into the proximal ureter and renal collecting system and advancing the stent over the wire. The distal end of the stent can be uncoiled, threaded into the ureter with forceps, and advanced into the bladder. Alternatively, the bladder can be opened and a guidewire passed into the ureteral orifice on the side of the injury. Through and through access across the anastomosis can be obtained and the stent advance across the full length of the wire into the collecting system. The bladder is subsequently closed with absorbable suture (2-0, 3-0) in 1 or 2 layers.
- After the ureteroureterostomy is complete, a portion of the omentum, if available, can be dissected free and wrapped around the ureter to minimize leak and adhesion.

- A suction drain is left in the pelvis for 2-3 days following repair. The bladder is drained postoperatively for 7-10 days and the stent for at least 14 days.

If the ureter has been ligated, release of the constricting suture or clip is first undertaken and a judgment made as to the integrity of the injury site. If the ureter is not deformed, it can be treated conservatively. It may be helpful to wrap the injured area with omentum to facilitate healing. This type of injury can be associated with a delayed ureteral stricture and one should have a low threshold to place a stent for 10-14 days. In the mid-ureter, if the site remains blanched or has evidence of crush injury, it should be resected and repaired with ureteroureterostomy over a stent. If injury occurs in the distal ureter, direct ureteroneocystostomy or psoas hitch repair is indicated.

An obvious acute thermal injury poses the greatest challenge, in that the extent of damage can be difficult to assess. We recommend wide resection of the damaged ureter and consideration of ureteroureterostomy only if tension-free anastomosis is possible. Otherwise, acute thermal injury in the mid-ureter should be repaired immediately with neocystostomy and psoas hitch.

Intraoperative injury to the mid or upper ureter may occasionally require complex repair due to a significant gap between the proximal ureter and the bladder. These techniques are reviewed in the sections that follow and may include Boari flap reconstruction, ileal interposition, or possibly renal autotransplantation. Another alternative is transureteroureterostomy, with mobilization of the injured ureter to the contralateral side for end to side ureteral anastomosis (**FIG. 37.7**). While this technique can be effective, critics highlight the risk of subsequent stricture at the site of repair putting both kidneys at risk for obstruction and functional compromise. Transureteroureterostomy is contraindicated in patients with a history of kidney stone formation. In cases involving long ureteral defects, it may be advisable to ligate the ureter above the site of injury and arrange for postoperative nephrostomy tube placement. This allows for staged repair after adequate patient counseling and additional evaluation.

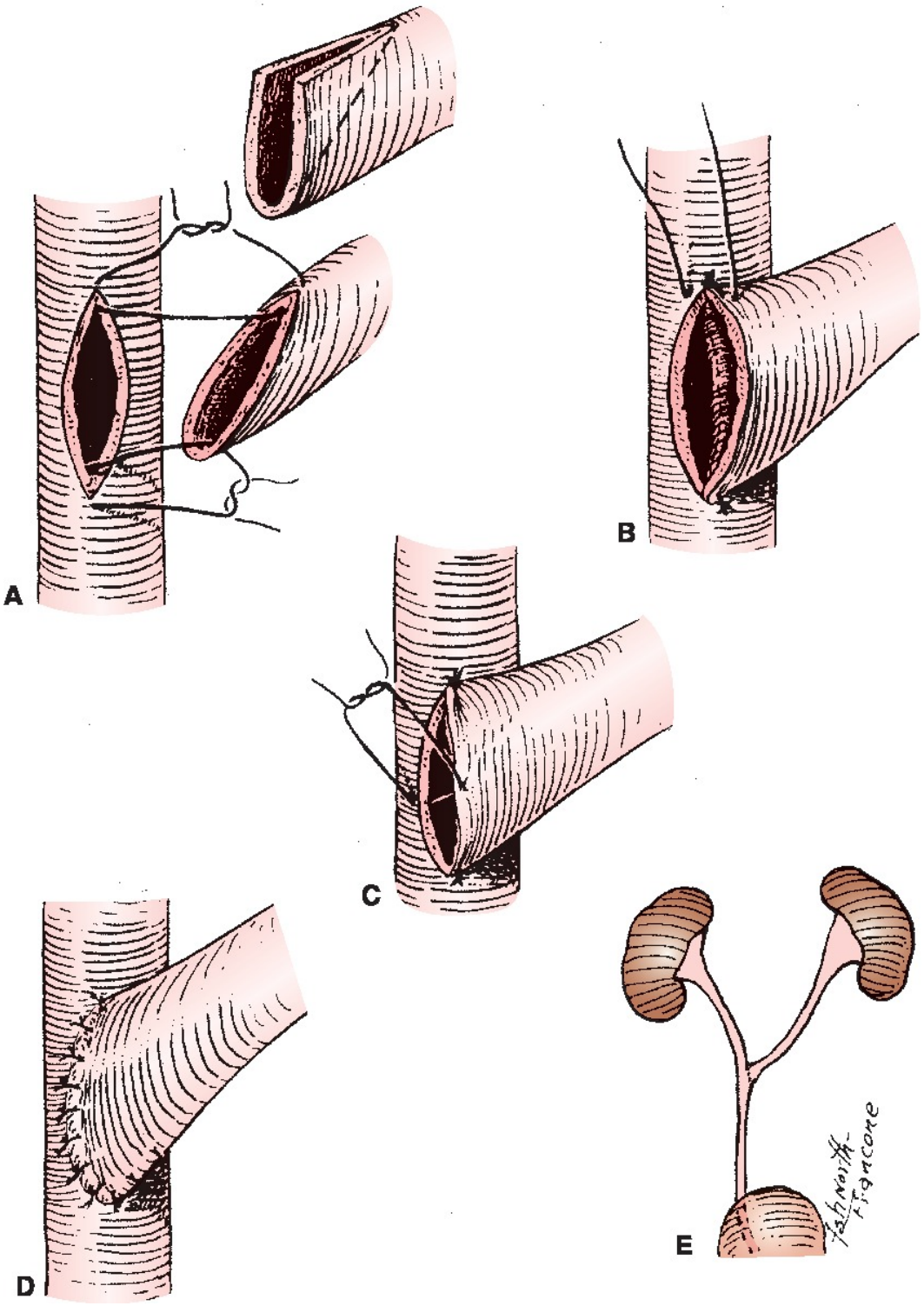



**FIGURE 37.7** Transureteroureterostomy. The injured ureter is mobilized to the contralateral side for end to side ureteral anastomosis. The

anastomosis is accomplished with interrupted sutures of fine absorbable suture. **A.** Ureteral spatulation and placement of tacking sutures to ureterotomy. **B.** Posterior wall fixation. **C.** Anterior wall fixation. **D.** The completed anastomosis. **E.** Left to right transureteroureterostomy.

## Ureteroneocystostomy

Injuries to the distal ureter can be corrected with direct anastomosis to the bladder. The simplest technique is an extravesical, refluxing reimplant (**FIG. 37.8**). The bladder is distended with saline through a Foley catheter and the catheter clamped. This allows for selection of a suitable reimplant site on the posterolateral aspect of the bladder and confirmation of adequate ureteral length for tension-free anastomosis without ureteral angulation. While it may seem suitable, one should avoid reimplantation into the dome of the bladder as this mobile section may allow the ureter to become kinked with filling leading to obstruction. Next, the distal ureter is freshened and spatulated. At the reimplant site, the peritoneum and detrusor muscle are incised with cautery for 1-2 cm. The detrusor muscle can be dissected free from the bladder epithelium using fine scissors. This is aided by the bladder distension and the epithelium becomes readily visible. Fine absorbable suture can be used to complete half the anastomosis, incorporating the epithelium, ureter, and detrusor muscle. The urothelium is then incised, allowing the bladder to decompress. A ureteral stent is placed and the anastomosis completed using the stent as a guide. The bladder can be refilled to insure a watertight connection, and the serosa and peritoneum closed loosely over the ureter with fine absorbable suture to provide additional security (**FIG. 37.8**).

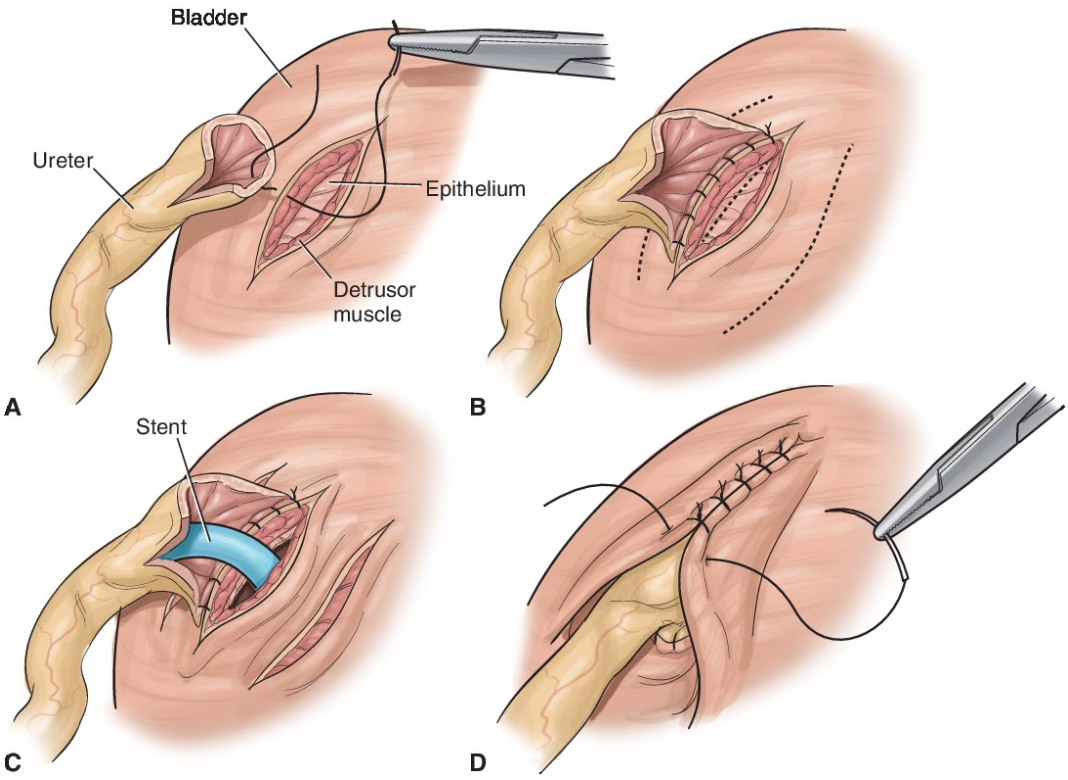



**FIGURE 37.8** Extravesical technique for ureteroneocystostomy. **A.** The distal ureter is freshened and spatulated for 1 cm. The detrusor muscle is incised for 1-2 cm on the posterolateral aspect of the bladder to expose the epithelium. **B.** The lateral aspect of the anastomosis is completed before incising the urothelium. **C.** The epithelium is incised and a stent introduced across the anastomosis. **D.** The ureteral anastomosis is completed, and the serosa is closed over the ureter.

It is also possible to perform ureteroneocystostomy using an intravesical technique. A midline cystotomy is made and a suitable site for reimplant identified. A hiatus is made in the bladder wall and

the ureter transferred to the interior. The ureter can be matured to the full thickness of the bladder using fine absorbable suture (**FIG. 37.9**).

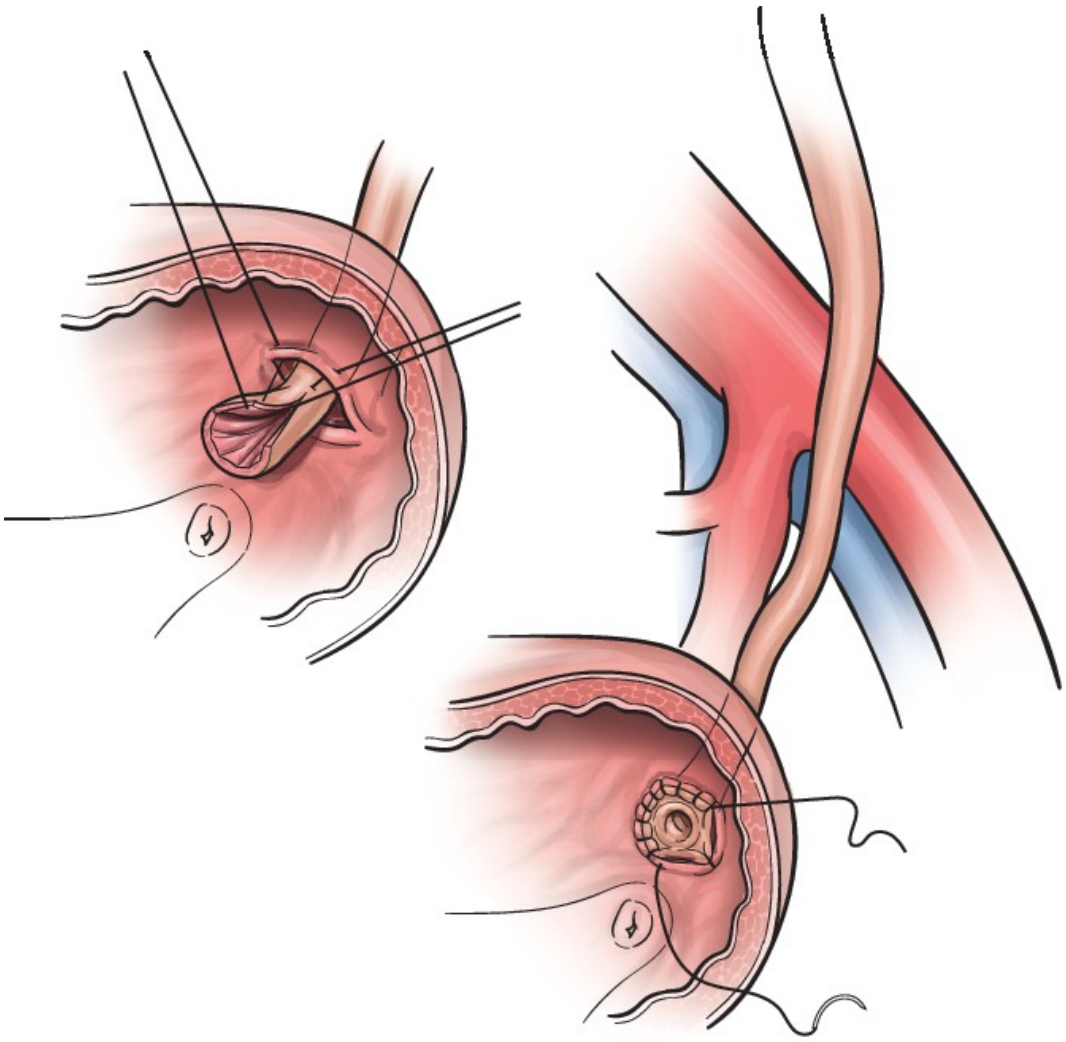


**FIGURE 37.9** Politano-Leadbetter intravescial technique for ureteroneocystostomy. After cystotomy, a hiatus is made in the bladder wall. The distal ureter is then pulled through this hiatus and fixed to the bladder wall using fine absorbable suture.

# Psoas Hitch

Mid-ureteral injuries above the pelvic brim can often be repaired by incorporation of a psoas hitch to the bladder. This procedure secures the bladder to the ipsilateral psoas muscle allowing for tension-free ureteroneocystostomy. The psoas muscle is exposed by opening the posterior peritoneum and three 2-0 nonabsorbable sutures placed in the psoas muscle belly. It is preferable to place the sutures parallel to the muscle fibers to avoid injury to the underlying genitofemoral nerve. The white band of the psoas minor tendon is easily identified and can often serve as a good anchorage. These sutures are set aside and the bladder distended to confirm adequate capacity and mobility. Peritoneal attachments to the bladder can be extensively divided to improve necessary mobility. The contralateral vascular pedicle can also be divided, but this is not routine. The bladder is then incised diagonally along the anterior dome to allow the posterolateral aspect to reach to the psoas muscle (**FIG. 37.10**). The previously placed sutures are fixed to the posterior aspect of the detrusor for anchorage to the psoas muscle, thereby shortening the gap to the distal ureter. The ureteroneocystostomy can be incorporated into the bladder closure undertaken perpendicular to the original incision. Care should be taken not to perforate the bladder epithelium with the anchoring sutures so as to avoid bladder stone formation (**BOX 37.2**).

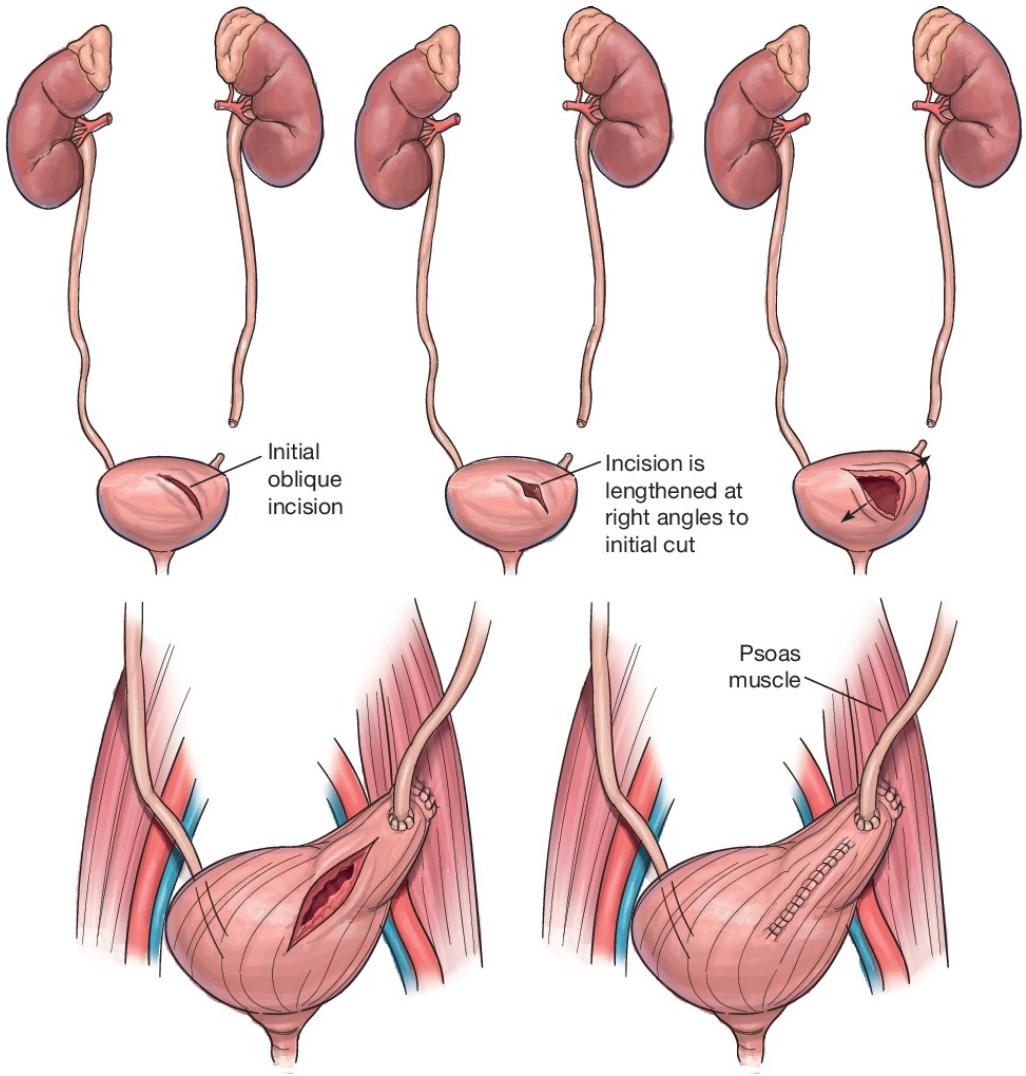



**FIGURE 37.10** Bladder elongation performed to allow a tension-free ureteroneocystostomy. The bladder is anchored to the psoas muscle ("psoas hitch") to avoid tension.

## BOX 37.2 STEPS IN THE PROCEDURE

### Ureteroneocystostomy With Psoas Hitch

- The peritoneum over the ipsilateral psoas muscle is opened sharply at the level of the pelvic brim.

- Three 2-0 nonabsorbable sutures are placed in the psoas muscle, parallel to the muscle fibers (to avoid injury to the underlying genitofemoral nerve) and set aside.
- The bladder is distended with saline through the Foley catheter to near full capacity.
- An incision is made in the bladder diagonally across the anterior dome. Full-thickness stay sutures are placed at the midpoint of this incision to provide traction.
- The nonabsorbable sutures are placed through the detrusor muscle. Care should be taken not to perforate the bladder epithelium with the anchoring sutures to avoid bladder stone formation. These are tied in sequence to anchor the bladder.
- Bladder closure is undertaken perpendicular to the original incision. If desired, the bladder closure can incorporate the site of ureteral reimplantation without the need for separate neocystostomy.
- Prior to implantation, the proximal ureter is mobilized sharply and spatulated for at least 1 cm. Ureteral vesical anastomosis is completed using fine absorbable suture in a tension-free fashion. The remainder of the bladder wall is closed using 2-0 or 3-0 absorbable suture in 1 or 2 layers.
- The perivesical fat and peritoneum can be closed over the ureterovesical suture line to provide additional coverage.
- Prior to completion of the bladder closure, a double-J ureteral stent 24-26 cm in length is passed into the ureter over a guidewire.
- Postoperatively, the pelvis is drained for 2-3 days, the bladder is drained for 7-10 days, and the stent kept in place for at least 14 days.

## Boari Flap

This technique can be used to repair injury to the proximal aspect of the mid-ureter. It is best used in a delayed fashion after additional workup and patient counseling is undertaken. This should include a cystogram and possible cystometrogram to insure adequate bladder capacity and compliance. Functional and anatomic bladder capacity can be reduced following Boari flap reconstruction, and patients should be counseled regarding this outcome.

The bladder is distended and the gap between ureter and bladder measured. A suitable wide-based flap (4-5 cm) originating from the cephalad margin of the bladder is outlined along a diagonal toward the contralateral side. The distal aspect of the flap should not be <2-3 cm in width. The flap is raised and extended to the spatulated ureter and sewn into a tube over a 16-18 fr catheter using absorbable suture (3-0, 4-0). The spatulated ureter can then be fixed end to end to the bladder tube with fine absorbable suture (**FIG. 37.11**). The repair is stented prior to completion and a pelvic drain placed. The bladder should be drained with a Foley catheter for 7-10 days. The stent can be removed after 2 weeks.

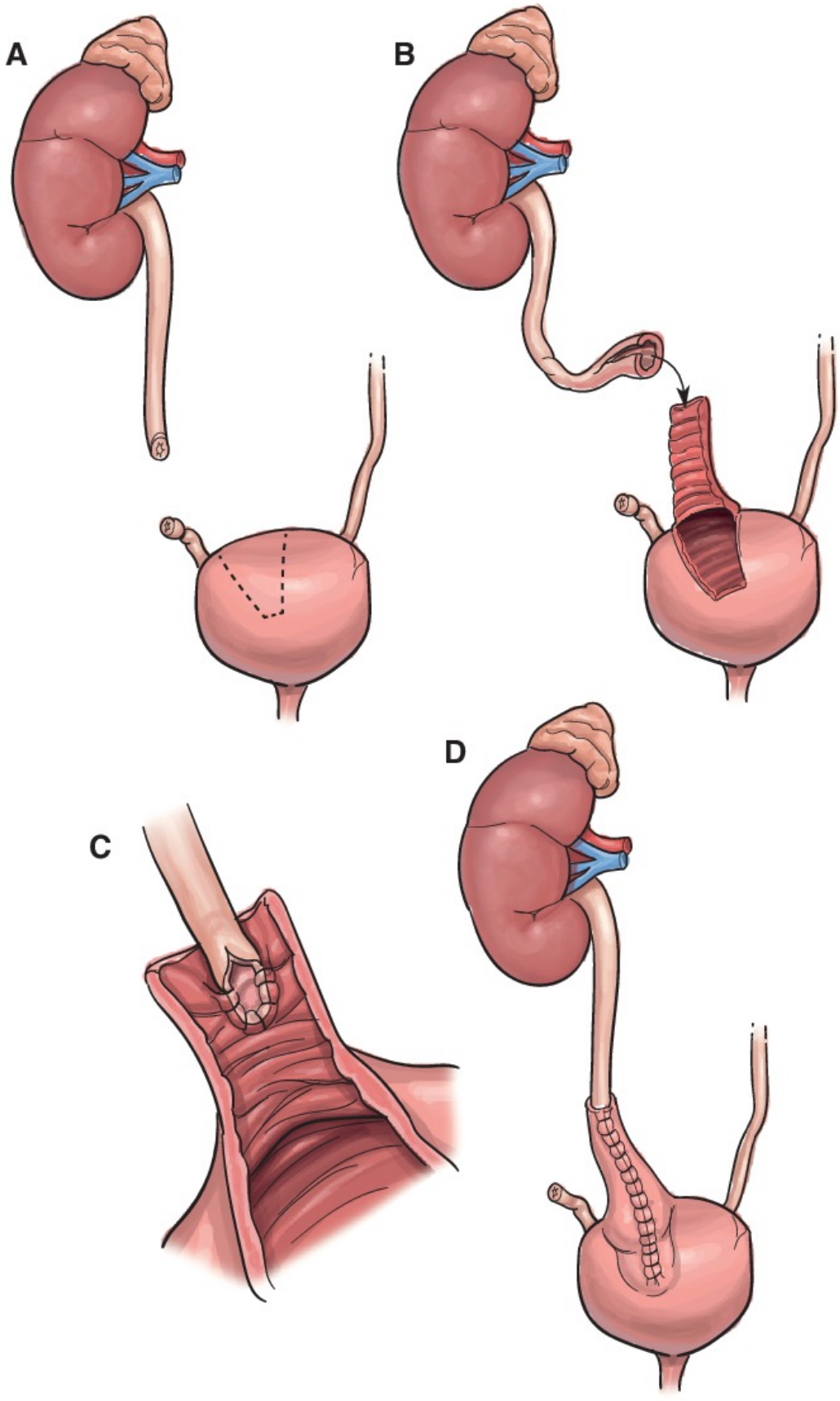

A
B
C
D

**FIGURE 37.11** Boari flap construction

## Ureteral-Ileal Interposition

Injuries to the upper mid or proximal ureter often require bridging a gap longer than the bladder can extend with psoas hitch or Boari flap construction. In these cases, a segment of ileum can be interposed between the ureter and bladder to reestablish continuity (**FIG. 37.12**). This procedure is best suited for delayed repair following patient counseling regarding the need for bowel anastomosis, extended postoperative recovery, effects on ipsilateral renal function, and the persistence of mucous in the urine.

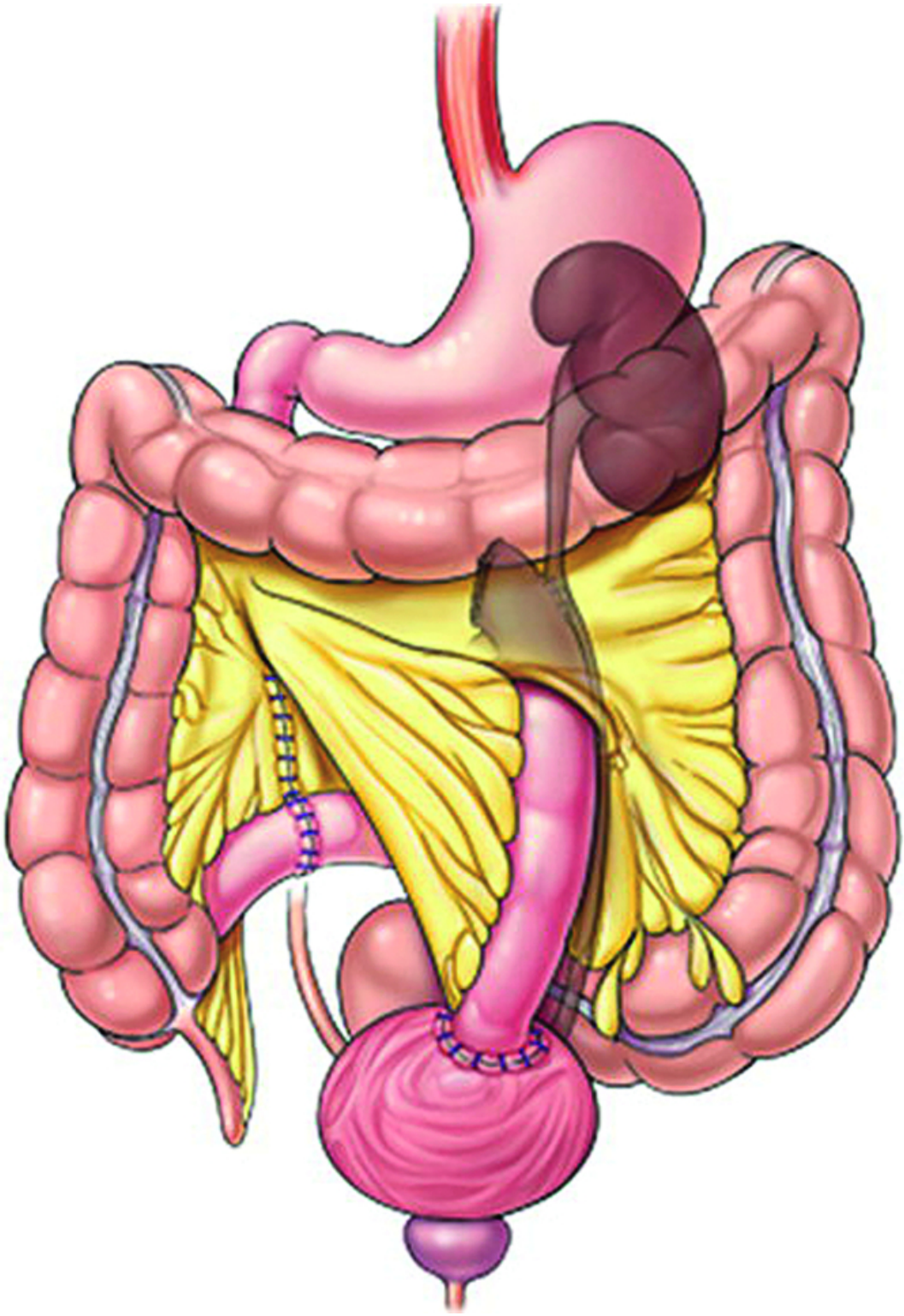


**FIGURE 37.12** Ileal interposition.

Following mobilization and spatulation of the distal ureter, the gap from ureter to bladder is measured. A psoas hitch can be incorporated in this procedure to shorten the segment of bowel needed for repair. Use of the shortest ileal segment possible minimizes metabolic derangement from urine resorption as well as mucous discharge with voiding. A segment of ileum adequate to bridge the ureteral defect is identified. This segment should be 12-15 cm proximal to the ileocecal valve in order to avoid malabsorption. The mesentery to the ileal segment is preserved and bowel continuity reestablished. It is recommended to place the ileal-ileal anastomosis cephalad to the segment for ureteral replacement. The ureter is brought through the posterior peritoneum and anastomosis to the ileum completed with fine absorbable suture over a stent extending to the bladder. The ileum is typically placed in a properistaltic orientation to facilitate urine drainage and minimize reflux. An end to side ileal-vesical anastomosis is completed over the ureteral stent. The pelvis is drained postoperatively. A Foley catheter is kept in place for 7-10 days and a cystogram obtained prior to removal to insure absence of extravasation. The ureteral stent can be removed after 2 weeks.

# INJURY TO THE BLADDER DURING GYNECOLOGIC SURGERY

## Hysterectomy

The bladder dome is at risk for perforation with both open and laparoscopic hysterectomy. During open surgery, this is most commonly associated with adhesiolysis, while trocar injury is associated with laparoscopic approaches. Decompression of the bladder prior to trocar placement or incision along the anterior midline is the key to avoidance.

The bladder base is at risk for injury during hysterectomy with mobilization of the cervix and subsequent colpotomy. Vaginal cuff closure may compromise the posterior bladder base at the vesicovaginal fold. Each of these events may result in vesicovaginal

fistula formation. Preparation of an adequate bladder flap is critical to avoiding this injury. Separation of the bladder from the surface of the cervix and anterior vagina is initiated with incision of the peritoneum in the vesicovaginal fold. The posterior bladder wall can then be mobilized with sharp dissection or judicious use of cautery. Counter traction on the bladder tissue aids in defining the proper plane. Alternatively, the bladder can be partially filled to define its posterior border during dissection. It is essential to gain enough separation between the bladder and vagina to facilitate colpotomy and cuff closure without encroaching on the bladder.

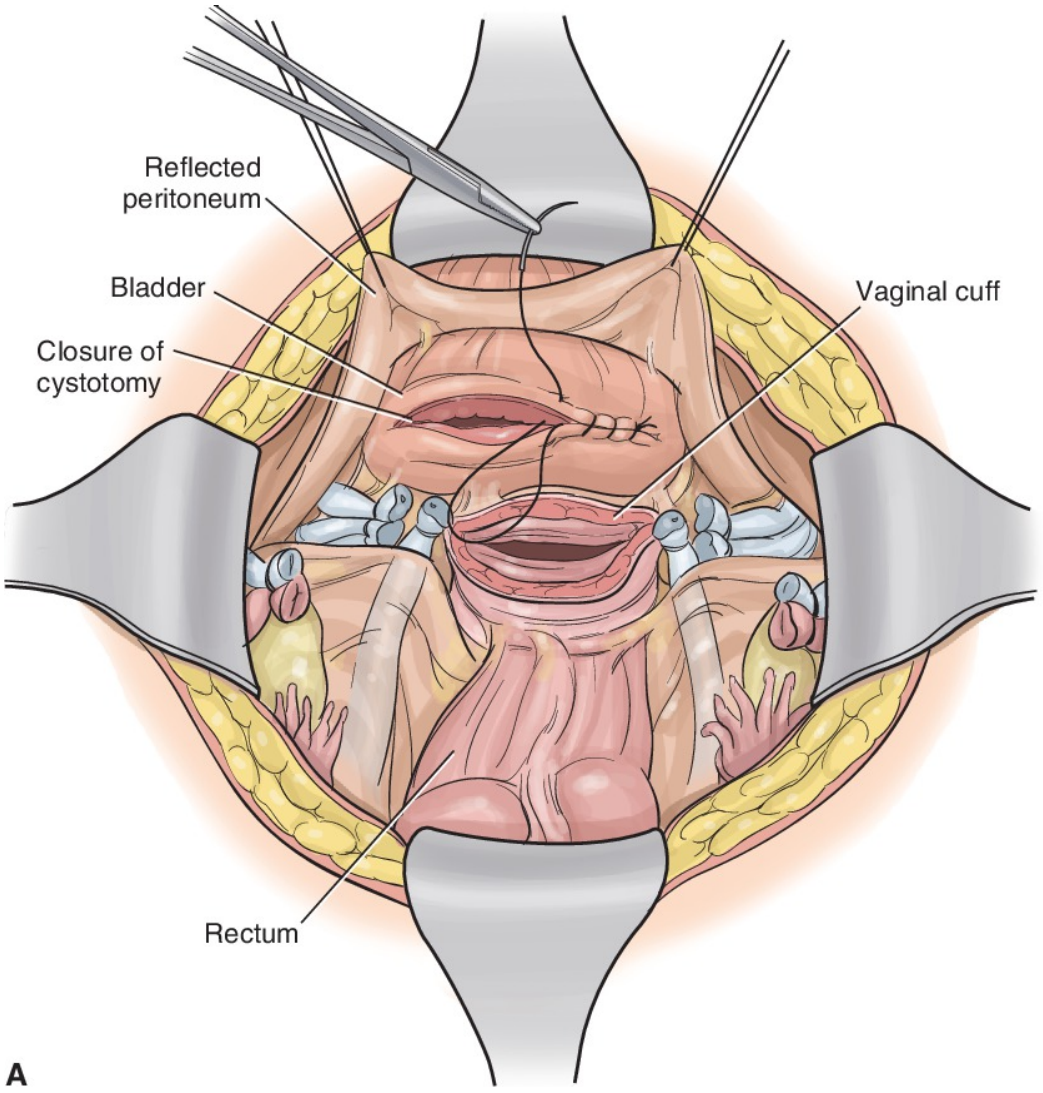
Intraoperative recognition of bladder perforation allows for acute repair and avoidance of postoperative urine leak or fistula. As stated previously, gynecologic surgery should include a final assessment of urinary tract integrity to exclude injury to the ureters, bladder, and urethra.

Bladder injury is often suggested by observing blood in the urine, or in the case of laparoscopic surgery, air entering the urine collection bag. Direct observation of urine extravasation into the abdomen or vagina with bladder distention confirms bladder injury. This can be aided by adding colorant to the fluid used to distend the bladder (methylene blue, indigo carmine, etc.). Cystoscopy can also help identify bladder injury.

In addition to identifying fluid extravasation from the bladder, it is also important to identify any visible suture material in the bladder associated with vaginal cuff closure. This circumstance may allow for delayed formation of a vesicovaginal fistula as the suture material dissolves, allowing for epithelialization of the suture tract to the vagina. If suture material is visible in the bladder, it should be removed, the bladder wall mobilized further, and the colpotomy reclosed. Tissue interposition may be used as an additional protection from fistula formation.

Intraoperative repair of cystotomy is usually possible. The key principle of bladder repair is adequate mobilization for tension-free tissue apposition (**FIG. 37.13**). Closure should be accomplished with absorbable suture (3-0, 2-0), and tissue interposition is typically recommended to prevent fistula formation. The bladder wall can be closed in 1 or 2 layers using either a running or interrupted

technique. A two-layer closure typically includes initial approximation of the epithelium and detrusor followed by a seromuscular second suture line. Options for tissue interposition for separation of the bladder from the vaginal cuff include omentum, a peritoneal rotation flap, or even a segment of the fibrofatty serosal tissue from the posterior bladder (**BOX 37.3**).



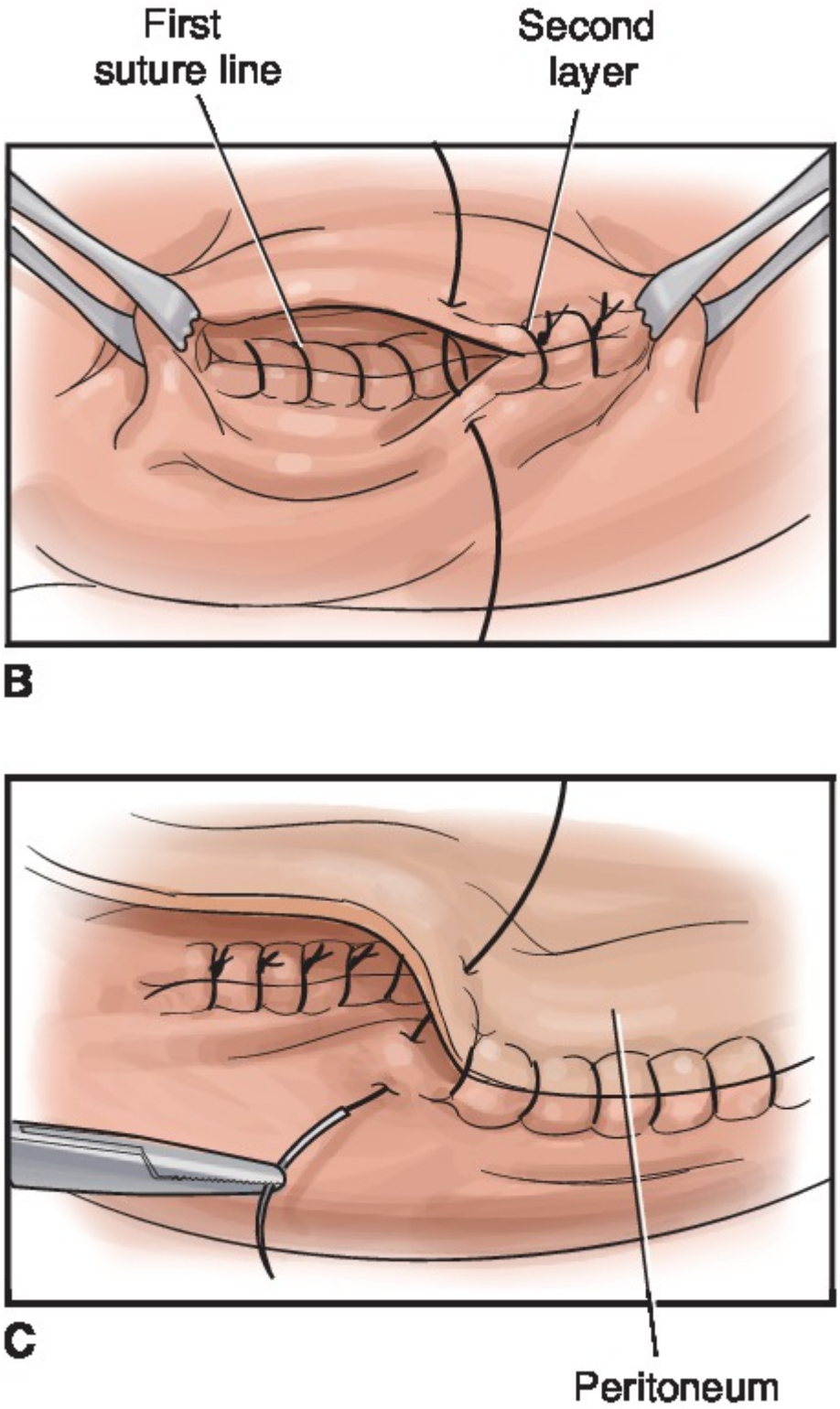



**FIGURE 37.13** Cystotomy repair, performed after completion of hysterectomy. **A.** The

epithelium and bladder wall are closed as a first layer. **B.** Closure of a second seromuscular layer. **C.** The peritoneum is closed over the cystotomy repair.

## BOX 37.3 STEPS IN THE PROCEDURE

### Cystotomy Closure

- Identification of bladder injury associated with colpotomy or cuff closure during hysterectomy
- Wide mobilization of the vaginal wall away from the posterior bladder
- 2-layer closure of the bladder wall using absorbable suture (2-0, 3-0)
- Tissue interposition between bladder and vagina using perivesical fat or peritoneum
- Vaginal closure using absorbable suture (2-0, 3-0)
- Bladder decompression for 7-10 days followed by cystogram prior to catheter removal

# Retropubic Colposuspension

As the bladder neck is in close proximity to the periurethral vaginal wall, it is possible to injure the bladder during retropubic colposuspension for stress incontinence. As permanent suture material is commonly used for this procedure, it is best to identify this occurrence intraoperatively, as delayed recognition is associated with recurrent infection, stone formation, and sometimes fistula. Cystoscopy with direct visualization is optimal for excluding foreign body in the urethra or bladder. If identified, it allows for suture removal and replacement. In the absence of an obvious bladder

laceration, bladder closure is not necessary. A period of postoperative bladder decompression may be helpful but does not appear essential.

## Surgery for Prolapse Repair

Surgery to correct prolapse includes both abdominal and vaginal approaches and may or may not incorporate synthetic mesh. In all cases, adequate separation of the bladder from the adjacent vaginal wall is the essential element for injury avoidance. Judicious use of cautery prevents thermal injury to the bladder wall. Hydrodissection with saline may also aid in identification and separation of tissue planes. During abdominal prolapse repair, simple bladder closure is adequate in the absence of synthetic mesh use. If synthetic mesh is incorporated in the prolapse repair, bladder closure with tissue interposition is recommended to minimize the risk of erosion. It is not necessary to abort the procedure in the event of a bladder injury, although this is at the discretion of the operating surgeon.

With regard to vaginal approaches to prolapse repair, identification and management principles of bladder injury are similar with the following caveats. The risk of vesicovaginal fistula formation is significantly greater with vaginotomy and greater still with the use of synthetic mesh. Meticulous bladder closure with tissue interposition is required.

In the event of bladder injury requiring suture repair and tissue interposition, postoperative bladder decompression for a period of 7-10 days is recommended. A postoperative cystogram is performed to exclude fluid extravasation.

## Sling Surgery

Placement of bladder neck or mid-urethral slings using a retropubic approach may result in bladder injury. This most commonly involves perforation with a preloaded trocar or suture carrier. It is unclear whether this risk is greater with a “top down” or “bottom up” approach. It is generally recommended the bladder be decompressed during trocar or suture carrier passage to minimize

perforation. In either case, intraoperative recognition is the key to avoiding postoperative sequelae, including persistent infection and stone formation. It is routine in these cases to perform cystoscopy for direct visualization of the bladder interior to exclude trocar injury or intravesical foreign body. If this should occur, the essential maneuver is withdrawal of the trocar or sling material. It is acceptable to redeploy the sling and subsequently confirm absence of intravesical injury. Some advocate a period of postoperative bladder decompression, but this does not appear essential.

# Postoperative Diagnosis of Bladder Injury

Bladder injury during pelvic surgery is most commonly manifested postoperatively as continuous incontinence from vesicovaginal fistula formation or urinoma formation leading to acute abdominal pain and chemical peritonitis. The former is diagnosed most accurately by a high index of suspicion, an accurate history, and physical examination including a tampon test. The patient will most typically describe continuous incontinence unassociated with urgency or exertion. There may be short periods of dryness with supine or sitting position owing to pooling of urine in the posterior vagina, but leakage is seen both day and night. This symptom is often seen immediately after surgery but may present in a delayed fashion 7-14 days postoperatively if the etiology is thermal injury or foreign body (suture, mesh) erosion as described previously. The technical aspects of vesicovaginal fistula repair are reviewed in Chapter 35.

The cause of postoperative urinoma formation from intra-abdominal or retroperitoneal urine leak is most accurately diagnosed by computed tomography (CT scan) including intravenous contrast with delayed images to interrogate the bladder. If the study is equivocal, a formal CT cystogram can be included in the protocol. It is important to evaluate the ureters as well as the bladder. In cases where synthetic mesh has been placed in proximity to the bladder, cystoscopy may be included to identify any intravesical foreign body.

Bladder decompression is primary management with consideration given for percutaneous drain placement. In the setting of ureteral injury, a stent or nephrostomy tube is indicated. Left untreated, the urinoma will resorb over time, but patient comfort and mitigation of infection may warrant more rapid evacuation. Abdominal exploration is not necessary in the absence of a suspected concomitant bowel injury or visible mesh in the bladder. A cystogram performed 7-10 days after bladder decompression is used to confirm resolution. In the event of a persistent leak, a foreign body reaction should be suspected and exploration with excision required.

# INJURY TO THE URETHRA DURING GYNECOLOGIC SURGERY

It is uncommon for the urethra to be injured during general gynecologic surgery. It is primarily during procedures to treat urinary incontinence that the urethra may be compromised. Diagnosis of urethral injury is best done intraoperatively, as immediate repair minimizes the risk of incontinence, stone formation in the setting of synthetic sling placement, fistula formation, or stricture. Cystoscopy should be routinely performed during procedures to treat urinary incontinence. Fluid extravasation or visible foreign body in the urethra should prompt urethral repair. The fundamental principles once again include adequate separation of the vagina and surrounding tissue from the urethra, tension-free primary closure with absorbable suture material to insure a caliber of >20 F, tissue interposition to minimize fistula formation, and postoperative urinary diversion. Fine absorbable suture of 3-0 or 4-0 gauge is satisfactory for urethroplasty. Foley catheter drainage for 7-10 days is recommended. Postoperative imaging is not commonly performed to evaluate urethral repair.

## KEY POINTS

- Injury to the urinary tract is a potential consequence of pelvic surgery. As the majority of injuries can be diagnosed intraoperatively, systematic assessment of urinary tract integrity should be part of the surgical plan.
- Intraoperative cystoscopy using either flexible or rigid instruments can aid in the diagnosis and management of urinary tract injury.
- Common sites for ureteral injury are found beneath the uterine vessels near the cardinal ligament, beneath the infundibulopelvic ligament and the tunnel of Wertheim.
- Signs and symptoms of postoperative urinary tract injury may include unilateral flank pain, fever, prolonged ileus, abdominal or pelvic fluid collection (urinoma), and continuous incontinence.
- Successful ureteral repair relies on careful mobilization, wide spatulation, use of fine absorbable suture (4-0, 5-0) for tension-free anastomosis, and temporary stenting.

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# CHAPTER 38

# MANAGEMENT OF OPERATIVE COMPLICATIONS TO THE GASTROINTESTINAL TRACT

Mitchel Hoffman and Emmanuel E. Zervos

**Anatomy**
Stomach
Small Intestine
Large Intestine
**Enterolysis**
**Management of Inadvertent Bowel Injury**
Repair Bowel Enterotomy
Monopolar and Bipolar bowel injury
**Management of Bowel complications**
Nonmalignant Small Bowel Obstruction
Malignant Bowel Obstruction
Fistula
Radiation Injury
Bowel Perforation
Acute Appendicitis
Ogilvie Syndrome (Colonic Pseudo-obstruction)

**Preoperative Preparation**
Consent
Stoma Planning
Nutrition
Bowel Preparation
Patient With Bowel Obstruction
**Procedures**
Appendectomy
Bowel Resection
Rectosigmoid Colectomy
Colorectal Anastomosis With a Circular Stapler
Hand-Sewn Anastomosis
Anastomosis With a Linear Stapler (Side to Side)
Ileostomy
Colostomy
Loop Ostomy Closure
End Colostomy Takedown
**Postoperative Care and Complications**
Wound Management
Small Bowel Anastomosis
Colorectal Anastomosis
Intestinal Stomas
Ostomy Closure

The female pelvic cavity is a confined space occupied by the female genitalia, the lower urinary tract, and the rectosigmoid colon.

Anatomically, these structures are intimately associated. Other portions of the intestinal tract may also occupy the pelvis including the cecum, appendix, and/or small intestine. As such, gynecologic disease and the complications resulting from its treatment frequently involve the urinary tract, the intestinal tract, or both. Similarly, primary disease of the urinary and intestinal tract may also mimic or influence manifestations of gynecologic disease.

A pelvic surgeon must have medical and surgical expertise in the management of specific types of intestinal disorders. With any type of operation, the abdominal surgeon must be prepared for the eventuality of intestinal injury or other intra-abdominal complications. For the gynecologic surgeon, common indications for intestinal surgery include resection of tumor and bowel obstruction. Urologic, gynecologic, colorectal, and surgical oncologists also perform exenterative surgery, urinary diversion, fistula repair, and surgery for severe radiation damage to the bowel. Pelvic reconstructive surgeons are called on to repair rectal prolapse. Bowel resection is occasionally indicated for infiltrating endometriosis. When operating for presumed gynecologic pathology, the gynecologic surgeon occasionally discovers a primary bowel disorder that requires surgical management.

The purpose of this chapter is to provide the gynecologic surgeon with basic information necessary for the surgical management of the intestinal tract as it relates to gynecologic disorders and surgery, and associated complications.

# ANATOMY

## Stomach

The distal esophagus and stomach are the most proximal organs of the gastrointestinal tract that reside completely in the abdominal cavity. The intra-abdominal esophagus ranges from 3 to 6 cm in length under normal anatomic conditions and is located in the epigastrium. The stomach is anatomically separated into the cardia, fundus, body, antrum, and pylorus. The cardia is the portion immediately surrounding the gastroesophageal junction, the fundus

is the upward extension of the stomach toward the dome of the left hemidiaphragm, and the antrum is the portion of the stomach between the incisura and the pylorus. The incisura is the notched portion of the stomach along the lesser curvature further demarcated by the prepyloric or vein of Mayo, which is a caudal coursing branch of the right gastric vein. The pylorus is the involuntary sphincter that controls passage of chyme into the small intestine (duodenum). Being a derivative of the foregut, the stomach receives its arterial blood supply from the lower thoracic aorta, the celiac trunk, and collaterals arising from the superior mesenteric artery (SMA) (**FIG. 38.1**).

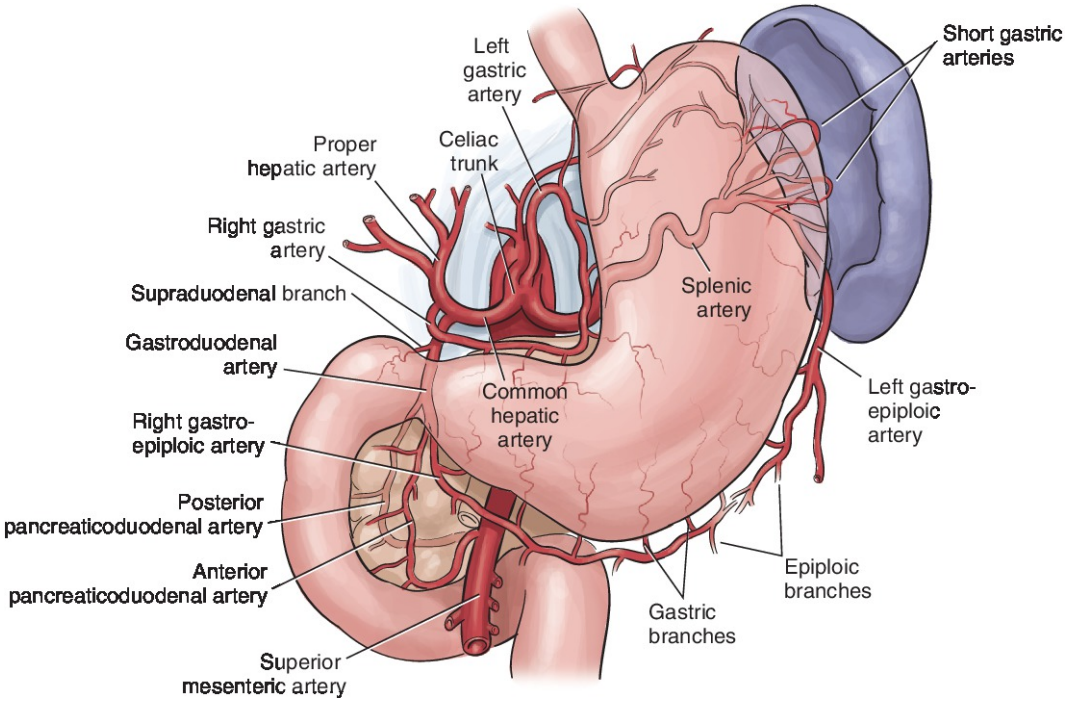



**FIGURE 38.1** Blood supply of the stomach.

# Small Intestine

The small intestine can be as long as 21 ft. Beginning at the pylorus of the stomach, the duodenum descends into the retroperitoneum to the ligament of Treitz and then reemerges into the peritoneal cavity

as the jejunum. The jejunum is ~8 ft in length whereupon it arbitrarily transitions to the ileum, which is ~12 ft in length and terminates at the ileocecal junction in the right lower quadrant. Clinically, the jejunum has greater luminal circumference, is slightly thicker, is more vascular, and is of deeper color than the ileum.

The blood supply of the jejunum and ileum is derived from the SMA. There is a progression of arcades from the intestinal branches that are single in the jejunum and increase to four or five in the ileum. The mesentery of the small intestine is fan shaped and is positioned obliquely over the posterior abdominal wall. (**FIG. 38.2**).

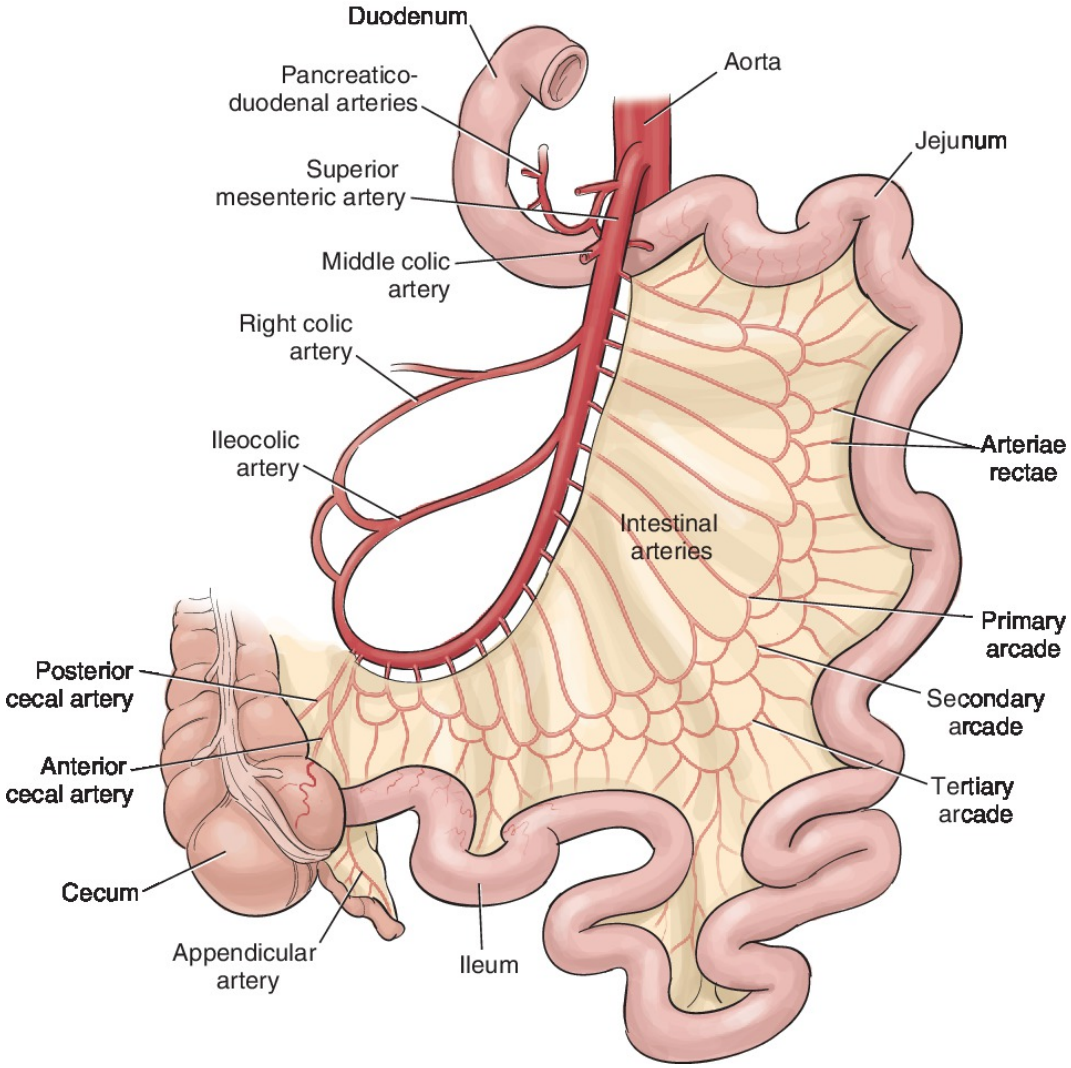


**FIGURE 38.2** Blood supply of the jejunum and ileum.

## Large Intestine

The large intestine extends from the cecum to the anus and is ~5 ft in length. Beginning at the base of the appendix and merging in the rectum, the external muscle layer of the colon is arranged in three longitudinal bands known as teniae. The colon also has small projections of peritonealized fat, known as appendices epiploicae.

The blood supply to the right colon and the left colon are derived from the superior and inferior mesenteric arteries, which form a rich collateral network within the mesentery as the arc of Riolan (proximal branches) and the marginal artery of Drummond (distal branches) (**FIGS. 38.3 and 38.4**).

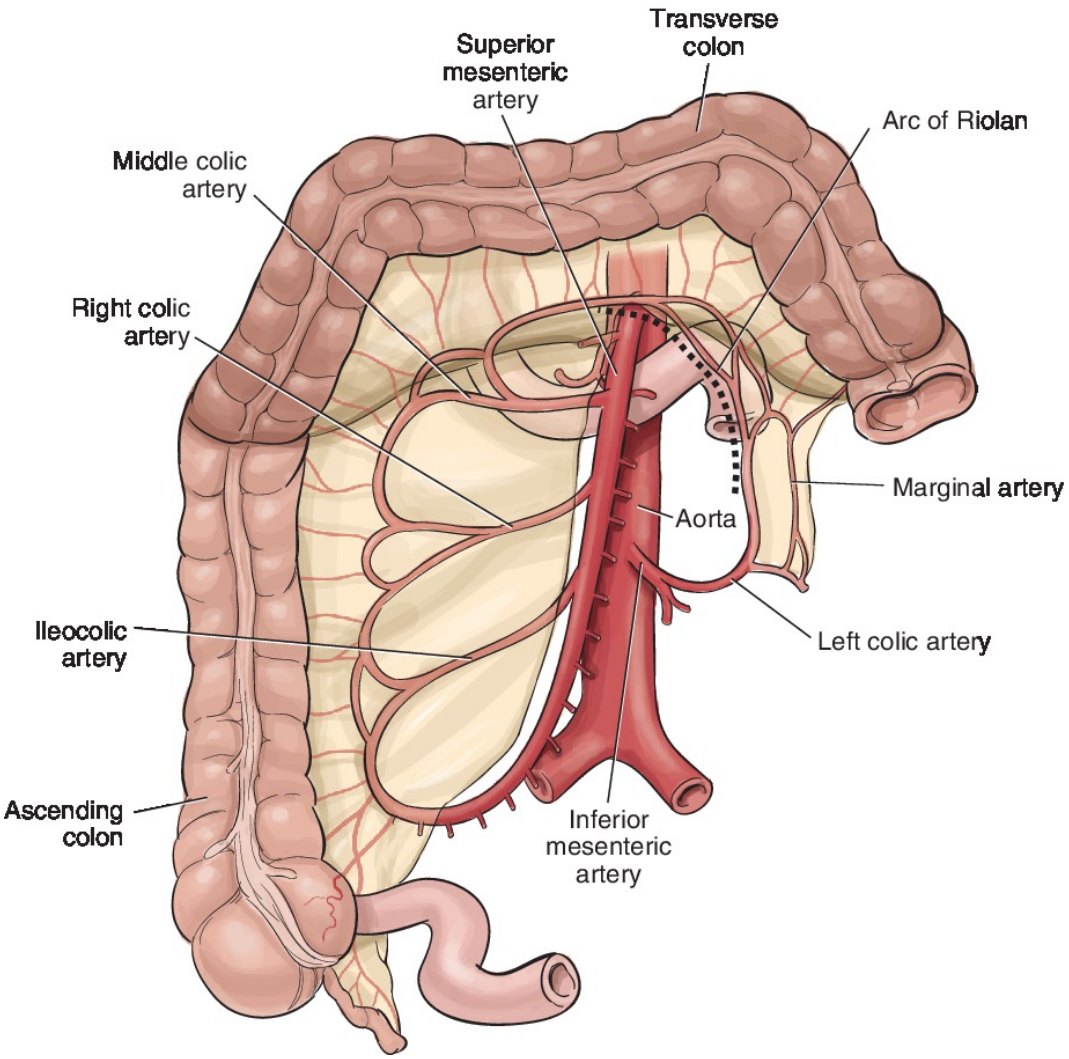



**FIGURE 38.3** Blood supply of the right and transverse colon.

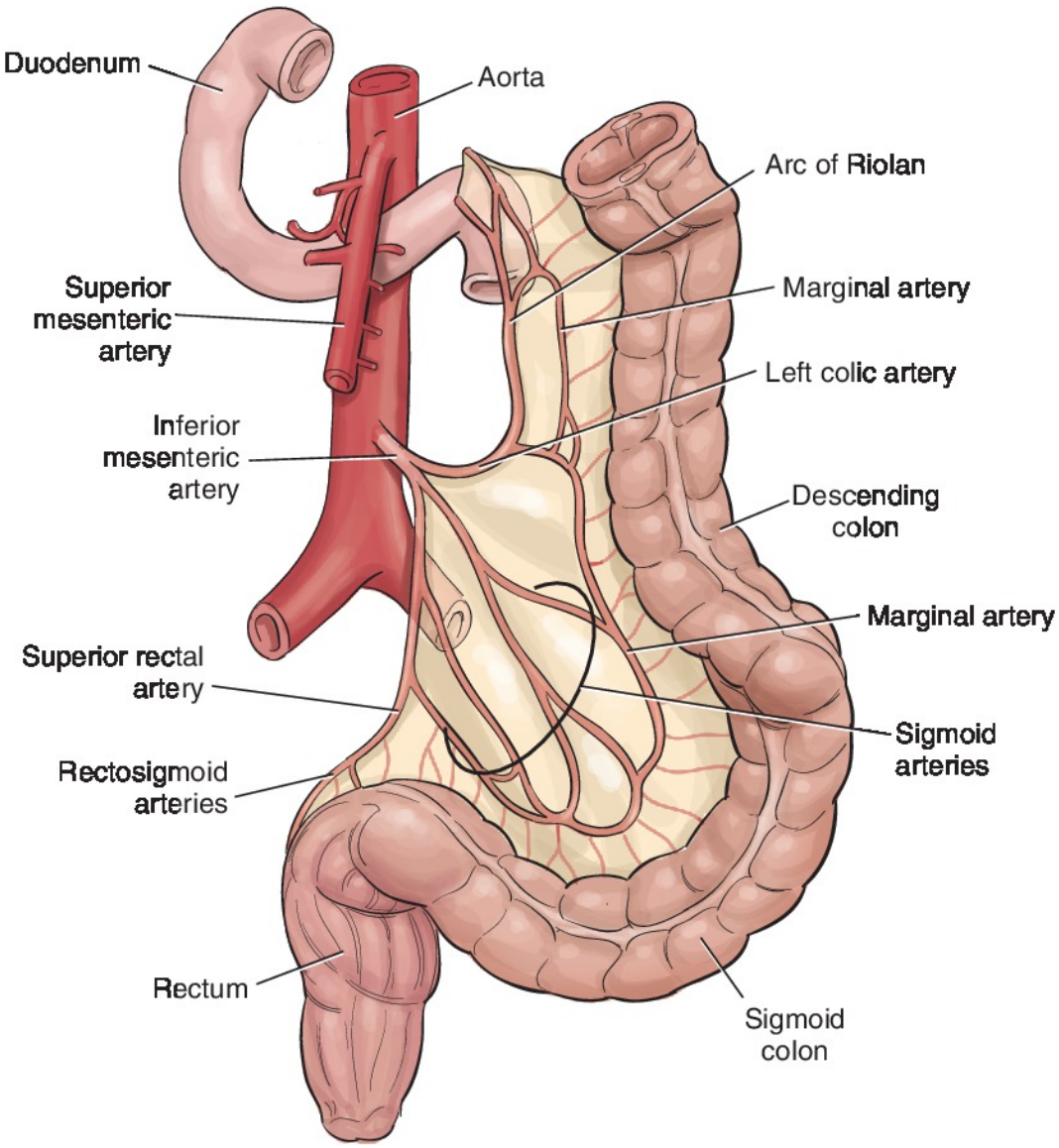



**FIGURE 38.4** Blood supply of the left colon.

The appendix arises at the base of the cecum distal to the ileocecal junction where the teniae coli originate. Native adhesions of the appendix, cecum, and/or terminal ileum to the parietal peritoneum are frequently present and may obscure the right infundibulopelvic ligament, adnexa, and/or ureter. From the cecum in the right lower quadrant, the partially peritonealized ascending colon extends cephalad to the hepatic flexure. The second portion or “c loop” of the duodenum is intimate with the hepatic flexure, and care must be

taken to avoid injury to the duodenum when mobilizing the hepatic flexure or resecting this part of the colon. Similarly, the right ureter courses within the retroperitoneum just posterior to the appendix and ileocecum and should be identified when mobilizing this portion of the colon especially during reoperative surgery or in a patient with a history of significant right lower quadrant pathology such as appendicitis or abscess arising from gynecologic pathology.

The transverse colon is the longest and most mobile colonic segment, extending from the hepatic to the splenic flexure. It is further attached to the stomach by the gastrocolic ligament, which is intimate with the greater curvature of the stomach and the transverse mesocolon/ventral surface of the colon. Careful separation of the gastrocolic ligament gains access to the lesser sac and is necessary for complete omentectomy. Again, care must be taken when mobilizing this portion of the colon, as excessive traction on the splenic flexure can cause downward tension on the splenocolic ligaments, which could result in capsular tear of the spleen creating troublesome and unnecessary hemorrhage.

The partially peritonealized descending colon extends from the splenic flexure to the sigmoid colon. The upper descending mesocolon is intimate with the kidney, which is close to the proper plane of dissection as this part of the colon is mobilized. The anatomic blood supply to the splenic flexure is less robust and more variable and is referred to as the watershed area due to this arterial variability. At the pelvic brim, the descending colon becomes completely intraperitoneal. Native adhesions of the sigmoid colon to the parietal peritoneum are frequently present and may obscure the left infundibulopelvic ligament, adnexa, and/or ureter. The sigmoid mesentery, with its root at the inferior mesenteric artery [IMA] is generous and extends to the posterior cul-de-sac. The rectosigmoid colon blood supply transitions to the lateral sides of the rectum.

The rectum follows the curve of the sacrum, increasing in size to form the ampulla (ie, fecal reservoir) just above the levator ani. The anorectal angle is formed here. Ventrally, the rectal wall is invested with a delicate layer of connective tissue known as “Denonvilliers” fascia after the French anatomist and surgeon. This fascial layer extends from the base of the cul-de-sac to the perineal body,

separating the rectum from the lower two-thirds of the posterior vaginal wall. During cephalad mobilization of an infiltrating cul-de-sac tumor, division of this fascia is useful for mobilizing the tumor and gaining additional rectal length before transection. The blood supply of the rectum is derived from the terminal branches of the IMA and hemorrhoidal branches of the internal iliac (hypogastric) arteries. There are vast anastomoses between these vessels along the rectal wall. The venous component includes anastomoses to the portosystemic circulation. These “portosystemic” conduits account for the higher propensity of rectal tumors to metastasize to the lung than the rest of the intraperitoneal colon (**FIG. 38.5**).

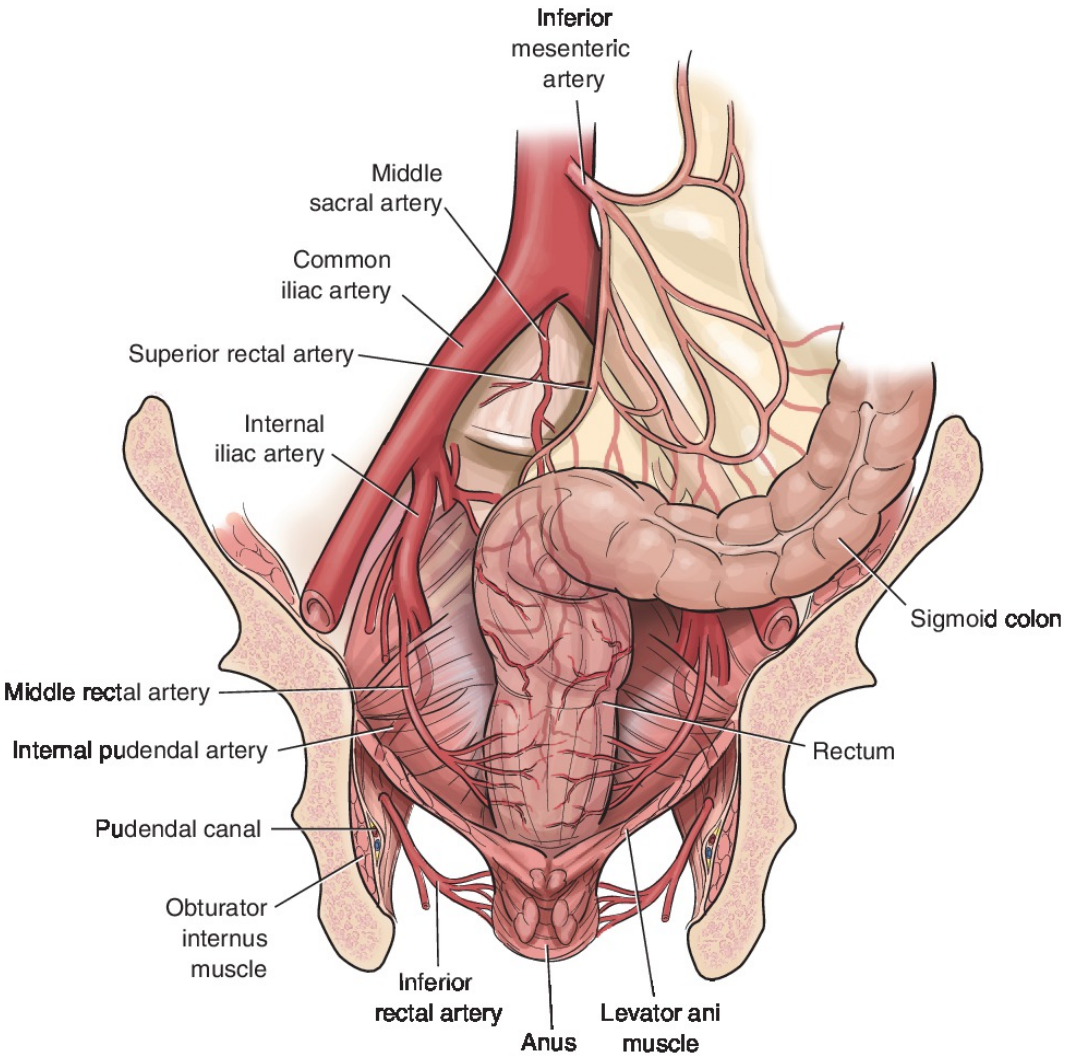



**FIGURE 38.5** Blood supply of the rectum.

# ENTEROLYSIS

Adhesions in the peritoneal cavity commonly occur in patients who have undergone prior surgery or have experienced an inflammatory process such as endometriosis, salpingo-oophoritis, appendicitis, and diverticulitis. Such adhesions frequently involve the intestinal tract and may lead to obstruction, obstipation, or pain. Bowel adhesions may interfere with access to the pelvis during surgery and/or may involve pelvic structures. Adhesiolysis in the abdomen and pelvis is a requisite skill for any surgeon who operates in the peritoneal cavity.

It is important for the surgeon approaching adhesiolysis to understand the cause of the adhesions and to know what operations the patient has previously undergone. The approach to intestinal adhesions is modified by factors such as prior radiotherapy, known inflammatory bowel disease, prior intestinal resection (with potential risk for short gut syndrome), carcinomatosis, and ascites.

In a patient with normal intestinal function and intestinal adhesions that will not interfere with the planned operation, lysis of such adhesions may not be indicated. In the setting of small bowel obstruction due to peritoneal carcinomatosis, prior abdominal surgery or peritonitis, examination of the small bowel from the ligament of Treitz to the ileocecal valve is necessary to ensure that downstream obstruction or impending obstruction is not overlooked as a transition point may not be present or obvious in the setting of more proximal obstruction.

When adhesiolysis is indicated, some general principles should be followed. Some adhesions are well exposed with clear lines for separation. Dividing these adhesions first will help restore normal anatomy and improve exposure to remaining adhesions. To the extent possible, the surgeon should define the direction of involved bowel loops before embarking on adhesiolysis. Gentle traction/countertraction is used to define lines of adhesion and to facilitate separation while avoiding traction injury and serosal tears. When segments of the intestine are densely adherent, use sharp dissection with scissors or a scalpel. In general, as adhesions become more dense, their separation requires progressively sharper

dissection. When known or suspected intestinal injury occurs due to adhesiolysis, control any gross contamination with bowel clamps or sutures, and tag these areas for later inspection or repair. It is critical to define a fixed point—either at the ligament of Treitz (moving forward) or at the ileocecal valve (moving backward)—to organize adhesiolysis.

# MANAGEMENT OF INADVERTENT BOWEL INJURY

In addition to the intimate anatomic relationship between the female genital tract and the rectosigmoid, colon, cecum, and appendix, intestinal adhesions in the pelvis are common. The widespread use of laparoscopy in gynecologic surgery places other portions of the intestinal tract at risk. During gynecologic surgery, occasional injury to the intestinal tract can be expected. Certain disease processes or operations may increase the likelihood of injury, such as obliteration of the posterior cul-de-sac (by endometriosis, salpingo-oophoritis, or malignancy), radical pelvic surgery, and extensive enterolysis. Most injuries will consist of an inconsequential seromuscular tear or full-thickness injury or laceration, which is closed with one or two layers of suture. A common approach to repair of limited enterotomy or serosal tear is included as a video adjunct to this chapter. More significant injuries, such as multiple enterotomies within a short distance of each other, are best managed with bowel resection and single anastomosis rather than multiple repairs (**VIDEO 38.1**).

## Repair Bowel Enterotomy

Full-thickness injury of the small bowel should be repaired perpendicular to the lumen to avoid constriction. This is less important when closing a large bowel colotomy because of the colon's larger luminal circumference. The underlying principles of repair include assurance of adequate blood supply, freedom from tension, meticulous closure with gentle tissue handling, and an inverting technique that approximates the tissues without

strangulating them. Sutures are placed 2-3 mm apart and may be run or interrupted. One- or two-layer techniques are acceptable. The authors use 3-0 polyglactin (Vicryl) or silk suture for the first layer and imbricate that closure line with interrupted 3-0 silk seromuscular sutures. These seromuscular reinforcing sutures are called Lembert sutures (**FIG. 38.6**).

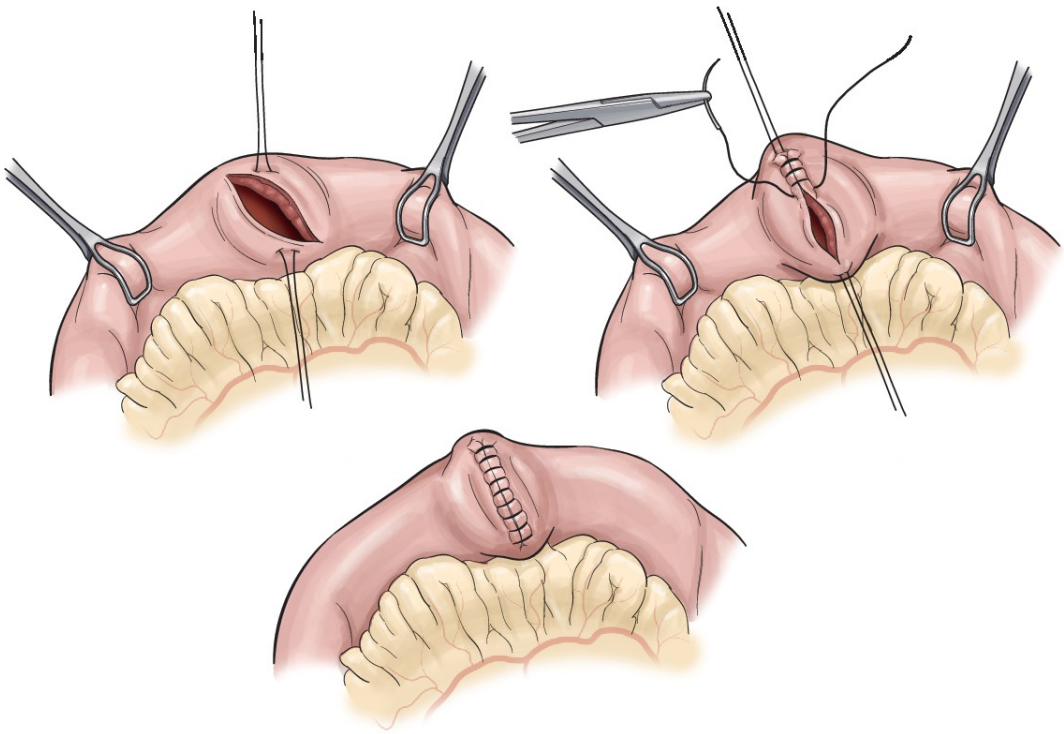


**FIGURE 38.6** Repair of a simple enterotomy.

## Monopolar and Bipolar Bowel Injury

Utilization of thermal energy is ubiquitous in minimally invasive surgery and open abdominal surgery. Injury to surrounding structures is the main risk, and potential consequences are greatest with damage to the intestine. Prompt recognition and management may prevent reoperation and other significant morbidity. Thermal bowel injury during laparoscopy is more likely with monopolar energy and may occur directly, by coupling energy to another instrument or

by insulation failure along the shaft of an instrument. Intraoperative recognition of monopolar thermal injury is more difficult than with gross anatomic loss of integrity (such as a full-thickness enterotomy) due to its variable and sometimes deceptively subtle appearance. Most thermal injury resulting in bowel perforation occurs 5-7 days after surgery. One should maintain a high level of suspicion during this time frame in cases where extensive monopolar adhesiolysis is performed. Injury of the intestine with bipolar energy is less likely than with monopolar energy and would most often be recognized immediately or upon disengagement of the device. Injury of the intestine due to bipolar energy occurs either by lateral thermal spread (such as when using a bipolar device for enterolysis) or by inadvertent incorporation of the intestine during application. Unrecognized thermal injury has the potential to progress to perforation in the early postoperative period leading to significant morbidity and reoperation.

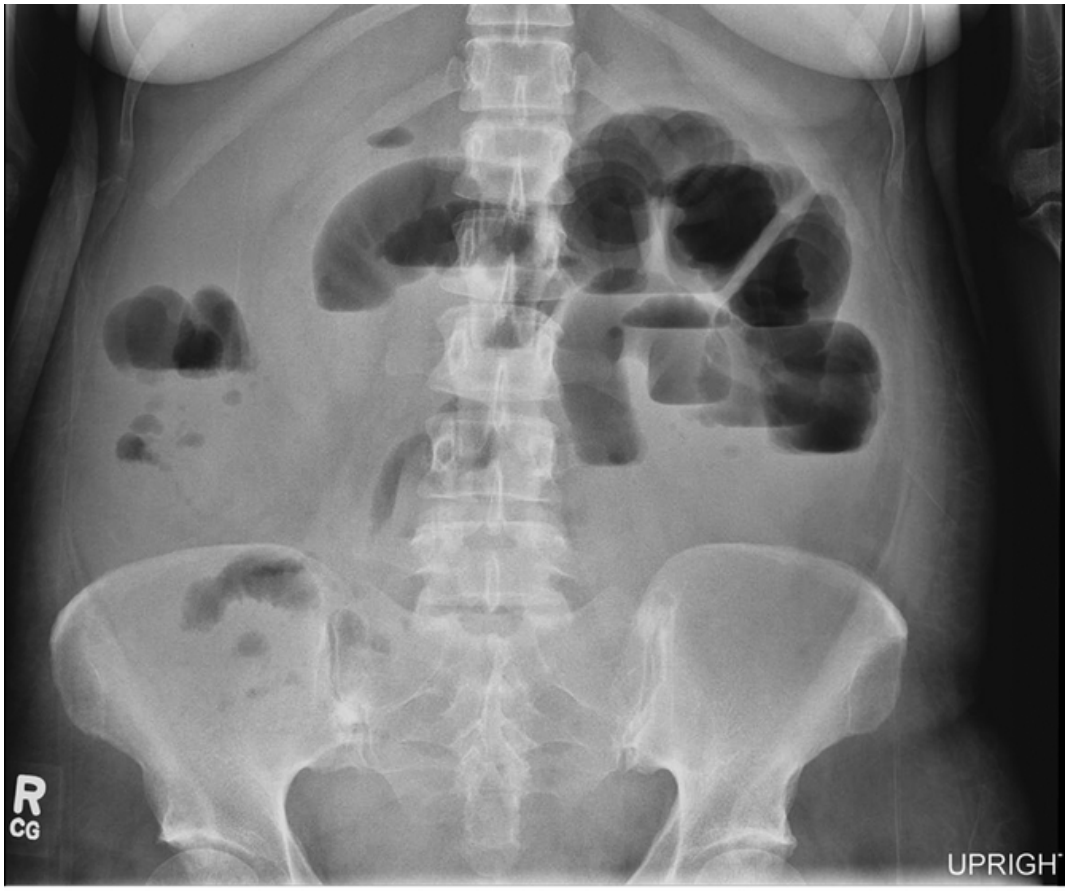
Management of thermal bowel injury is highly individualized according to the surgeon's impression of the extent of damage. Blanched, contracted tissue should be considered nonviable. There may be at least several millimeters of less apparent damage beyond the apparent injury. A limited, superficial cautery burn witnessed by the surgeon generally requires no treatment. If concern exists, the area may be oversewn with inverting seromuscular (Lembert) sutures. More substantial thermal damage requires full-thickness resection (including a normal-appearing margin) and repair.

# MANAGEMENT OF BOWEL COMPLICATIONS

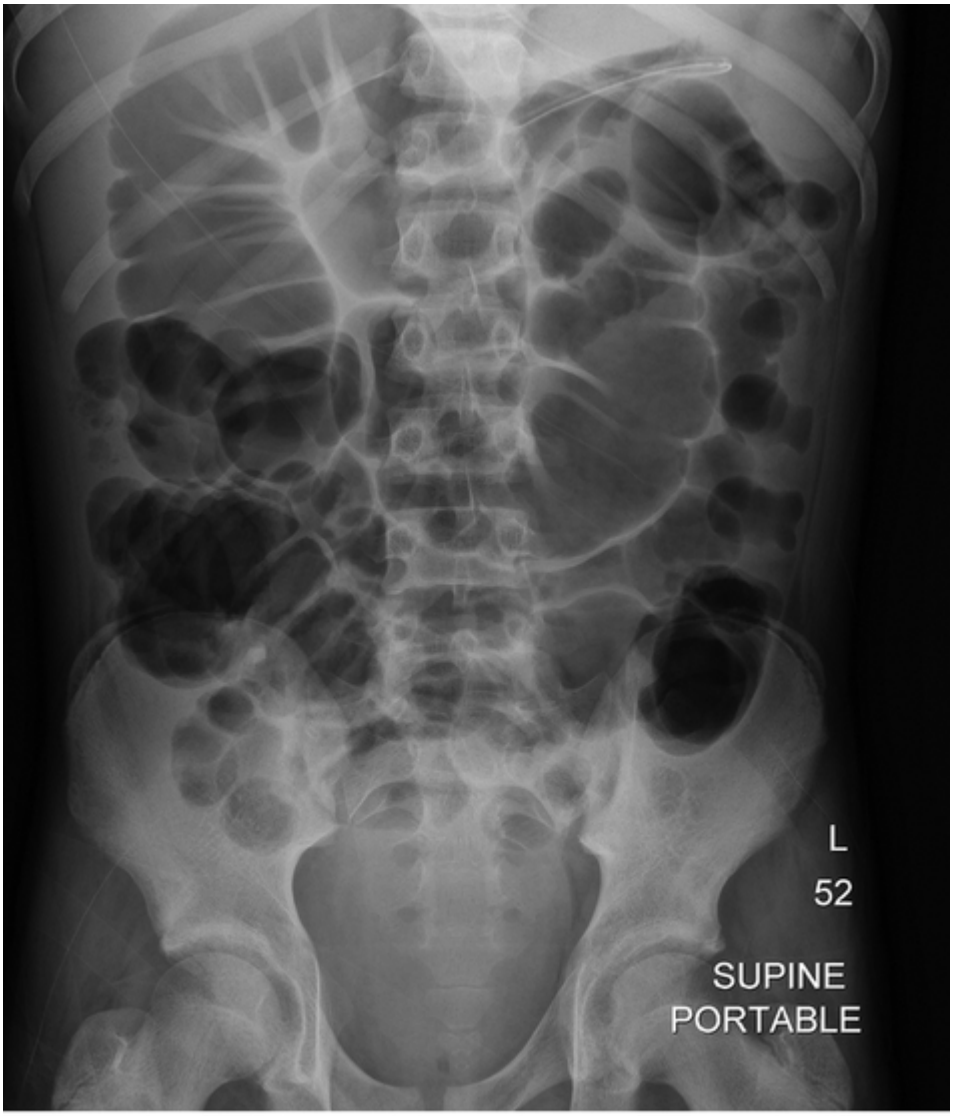
The gynecologic surgeon must be familiar with the management of bowel obstruction. In women who have undergone prior surgery or have experienced an extensive inflammatory process (eg, appendicitis, oophoritis, diverticulitis, endometriosis), small bowel obstruction may develop secondary to surgically induced adhesions or internal hernia formation. When persistent obstruction is secondary to adhesions, simple adhesiolysis may resolve the

obstruction. Occasionally, however, resection of a nonviable segment involved in the obstructive process is necessary.

In the setting of cancer, the gynecologic surgeon must manage bowel obstruction in a variety of settings. Epithelial ovarian cancer has a propensity toward intra-abdominal spread and may present with bowel obstruction. When the disease recurs and progresses, it is not uncommon for the patient to develop intestinal obstruction. Although other gynecologic malignancies may also cause bowel obstruction secondary to intra-abdominal carcinomatosis, ovarian cancer is by far the most common with malignant obstruction occurring in as high as 42% of patients with advanced ovarian cancer. Small intestinal obstruction is roughly twice as common but colonic obstruction, or both can also occur. The prognosis for patients with inoperable malignant small intestinal and colonic obstruction is extremely poor with survival ranging from weeks to just a few months. Decisions regarding surgical intervention in these patients must be made only after goals of care are established and with active involvement of the patient and family in the decision-making process (**FIG. 38.7A** and **B**).




A




B

**FIGURE 38.7** **A.** Upright x-ray showing air-fluid levels and dilated loops of small bowel consistent with small bowel obstruction. **B.** Supine radiograph showing dilated loops of large bowel without rectal gas or stool. This is consistent with a large bowel obstruction.

A contemporary analysis of patients with malignant bowel obstruction due to ovarian cancer undergoing surgical intervention found symptomatic improvement in 88% of patients at 30 days and 61% at 60 days with median survival just over 6 months. Endoscopic intervention (with palliative, decompressive procedures) yielded much less durable relief of symptoms of just over 2 months. The same authors reviewed 141 patients undergoing surgical or endoscopic procedures for symptoms of malignant bowel obstruction of all types; this review showed that the presence of carcinomatosis, ascites, or multifocal obstruction led to gastrostomy tube placement rather than more definitive interventions like resection, diversion, or bypass.

## Nonmalignant Small Bowel Obstruction

The most common causes of nonmalignant postoperative bowel obstruction requiring re-exploration are adhesions, internal herniation, and occult contained bowel perforation. Management of presumed nonmalignant bowel obstruction includes early establishment of the location and grade of obstruction using contrast studies after a short trial (~3 days) of nasogastric decompression and IV hydration. If a patient remains obstructed after this trial period and imaging studies, confirms mechanical (not ileus type) obstruction then surgical intervention is recommended. This approach has resulted in shorter lengths of stay and reduced costs in modern series, especially in the acute care surgery literature. In patients with early postoperative bowel obstruction, it is critical to establish a timeline for surgical intervention and adhere to it if the patient is medically fit to undergo reoperation. Failure to do so results in prolongation of necessary operative intervention, malnutrition, deconditioning, and sometimes irreversible inanition.

This algorithm is modified in select patients when potential self-limited causes of obstruction such as anastomotic edema or other reversible postoperative complications such as abscess or ileus can be managed nonoperatively. In these cases, if early postoperative

obstruction does not resolve within 2 weeks of surgery, then surgical intervention is warranted and should be planned prospectively as one approaches this milestone without progress toward resolution. **FIGURE 38.8** demonstrates intraoperative findings in a patient with bowel obstruction due to internal herniation. **FIGURE 38.9** shows a rare instance of bowel herniating through a dehisced vaginal cuff resulting in an incarcerated hernia.

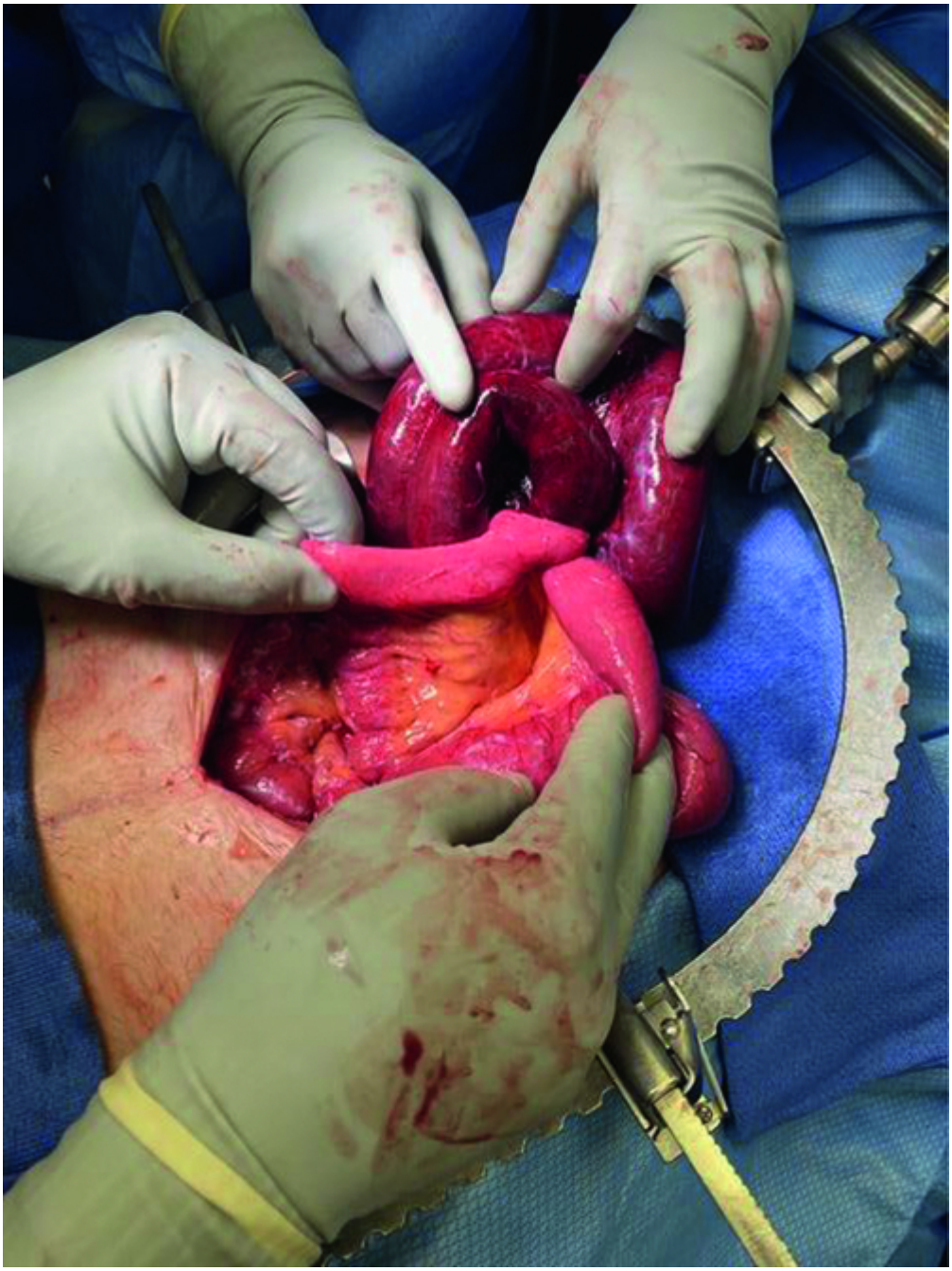


**FIGURE 38.8** Incarcerated internal hernia

**FIGURE 38.9** Ischemic bowel herniating through vaginal cuff following hysterectomy.

## Malignant Bowel Obstruction

Regardless of the origin of malignant bowel obstruction, it is important to undertake a thorough discussion to establish goals of care and ensure that the patient and family understands the implications of aggressive surgical management and potential for extended recovery in the setting of limited life expectancy.

Where there is an occurrence of extensive ascites, bulky intra-abdominal tumor, an ileus-type pattern suggesting functional obstruction, the patient is malnourished (albumin <3 g/dL), or generally in poor condition (American Society of Anesthesiologist Class ≥3, ECOG Score ≥ 2), surgical management of the obstruction is unlikely to provide benefit. A percutaneous gastrostomy tube may provide substantial relief and free the patient from the discomfort of a nasogastric tube and facilitate discharge from the acute inpatient setting. Some women with left colon obstruction may be palliated with an endoscopically placed, expandable rectal stent. Select patients with advanced ovarian cancer and persistent obstruction do appear to benefit from surgical intervention.

Due to extensive carcinomatosis, the intra-abdominal anatomy in these patients may be difficult to establish. The unobstructed proximal small bowel is freed to the extent possible, and a simple bypass to the proximal colon is carried out. In the presence of large bowel obstruction, a proximal diverting ostomy will generally be necessary. Even in the presence of obvious small bowel obstruction, whenever possible, the large bowel should be evaluated preoperatively for concomitant obstruction. Performing a contrast enema prior to exploration for malignant small bowel obstruction will provide assurance that resecting or bypassing small bowel to relieve obstruction will not be undermined by existing or impending downstream colonic obstruction.

Small bowel obstruction following radiotherapy for a gynecologic malignancy requires a more calculated approach predicated on experience operating on radiated bowel. These obstructions typically occur in the terminal ileum, although coexistent rectosigmoid colon injury is not uncommon. As such, both areas should be evaluated prior to surgical intervention. Surgical management of radiation-induced small bowel obstruction remains controversial. Some experts recommend bypass of the obstruction, while others believe that the damaged bowel should be resected with primary reanastomosis. Simple bypass involves a side-to-side anastomosis of the proximal uninvolved small bowel to a nonirradiated portion of the colon (**FIG. 38.10**). This is the quickest and easiest surgical intervention. Advantages of this approach include the avoidance of

extensive dissection of matted loops of bowel and risk of additional injury as well as unveiling raw, previously irradiated surfaces that can bleed, cause pain, or serve as a nidus for subsequent obstruction. The side-to-side anastomosis ensures a good blood supply, avoids the need for a mucous fistula, and may allow the remainder of the bowel to provide some absorptive capacity in cases of only partial obstruction; this is especially important when there is a short afferent limb. It also minimizes the risk of injury to other organs or structures, such as the ureter or vascular system. Overall, the results of simple bypass for these patients are reasonably good.

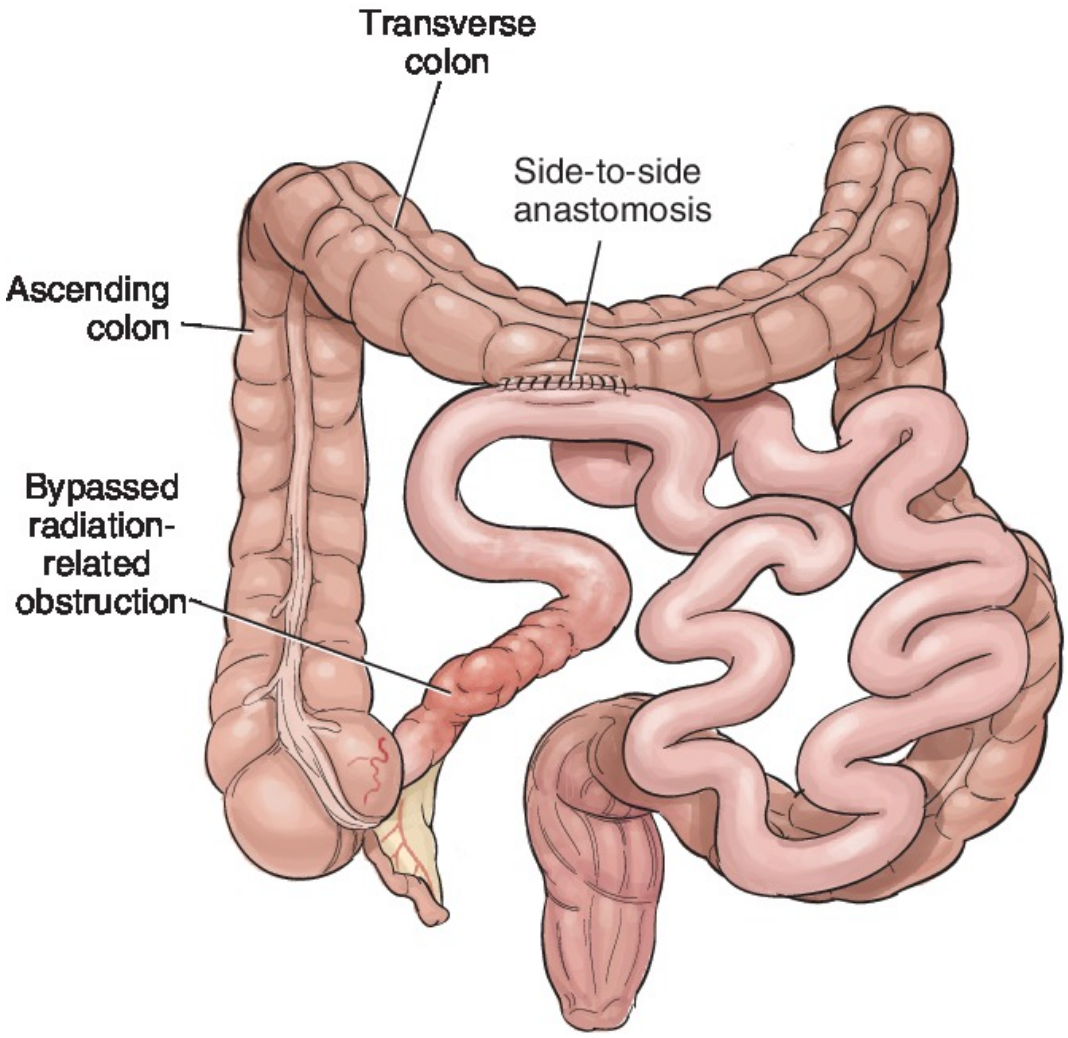



**FIGURE 38.10** Simple side-to-side anastomosis of proximal small bowel to

transverse colon in order to bypass radiation-related obstruction of the terminal ileum.

If the fecal stream is incompletely diverted, there is the potential for development of blind loops and/or fistula formation of the remaining damaged and potentially necrotic bowel. Individuals at risk for fistula formation include those who have received >50 Gray to the pelvis, are thin, elderly, or have significant medical comorbidities including arteriosclerosis, hypertension, diabetes. An end-to-side or end-to-end enterocolostomy without resection and with one or two mucous fistulae is an alternative to simple bypass (**FIG. 38.11**). The main advantage is complete diversion of the fecal stream from the damaged segment and thus avoidance of subsequent fistulization from this area. This type of procedure is often used to manage a postirradiation enterovaginal fistula.

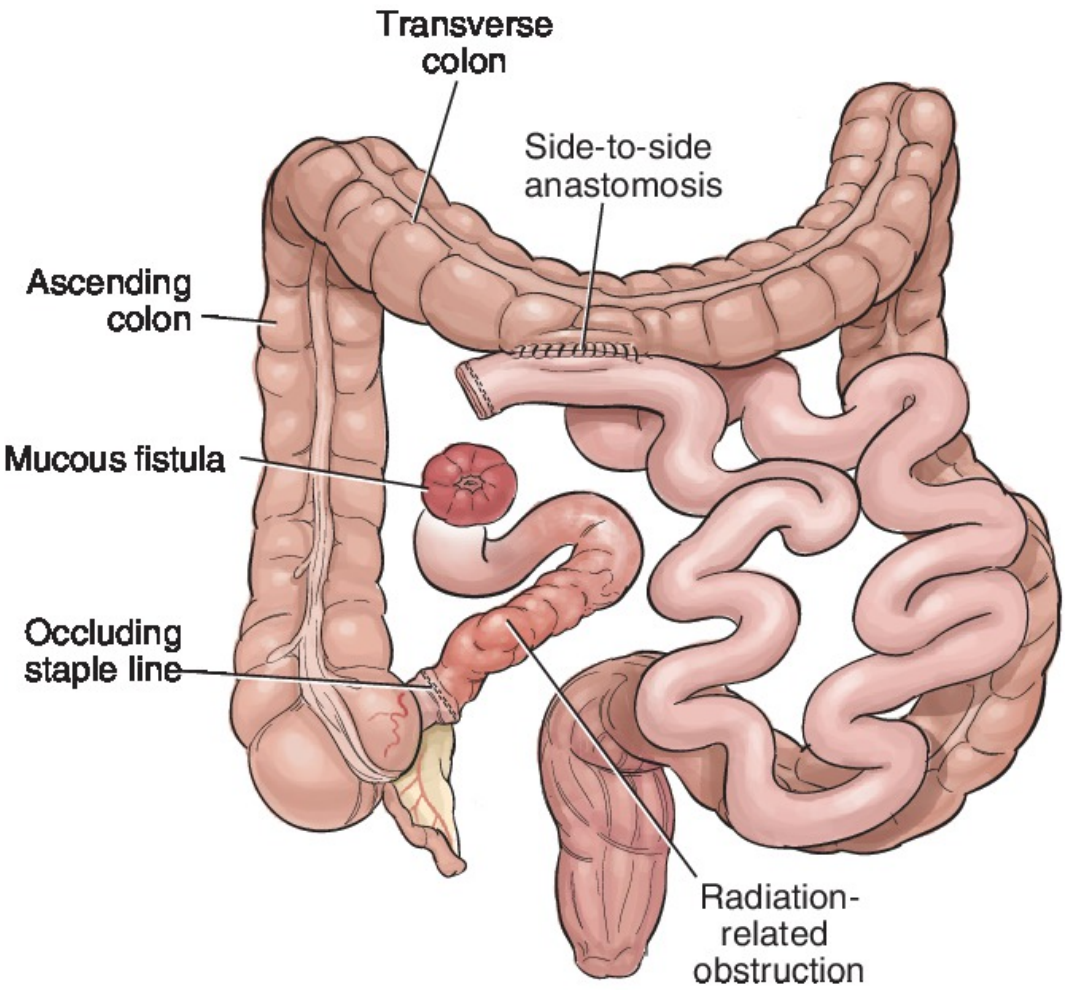



**FIGURE 38.11** Enterocolostomy that both bypasses and diverts the fecal stream from the obstructed ileum.

Resection with anastomosis includes removal of all diseased intestine and anastomosis of minimally radiated bowel (**FIG. 38.12**) and precludes the need for a mucous fistula. Depending on the operative findings, this may be an extensive and time-consuming surgery that frequently leaves the remaining bowel exposed to a raw, irradiated pelvis. Other potential disadvantages of resection include a less than optimal blood supply at the anastomosis. Surgery in a radiated pelvis also risks injury to other structures such as the

bladder, colon, ureter, and major blood vessels. Resection also can result in shortening of the functional small intestine (**FIG. 38.12**).

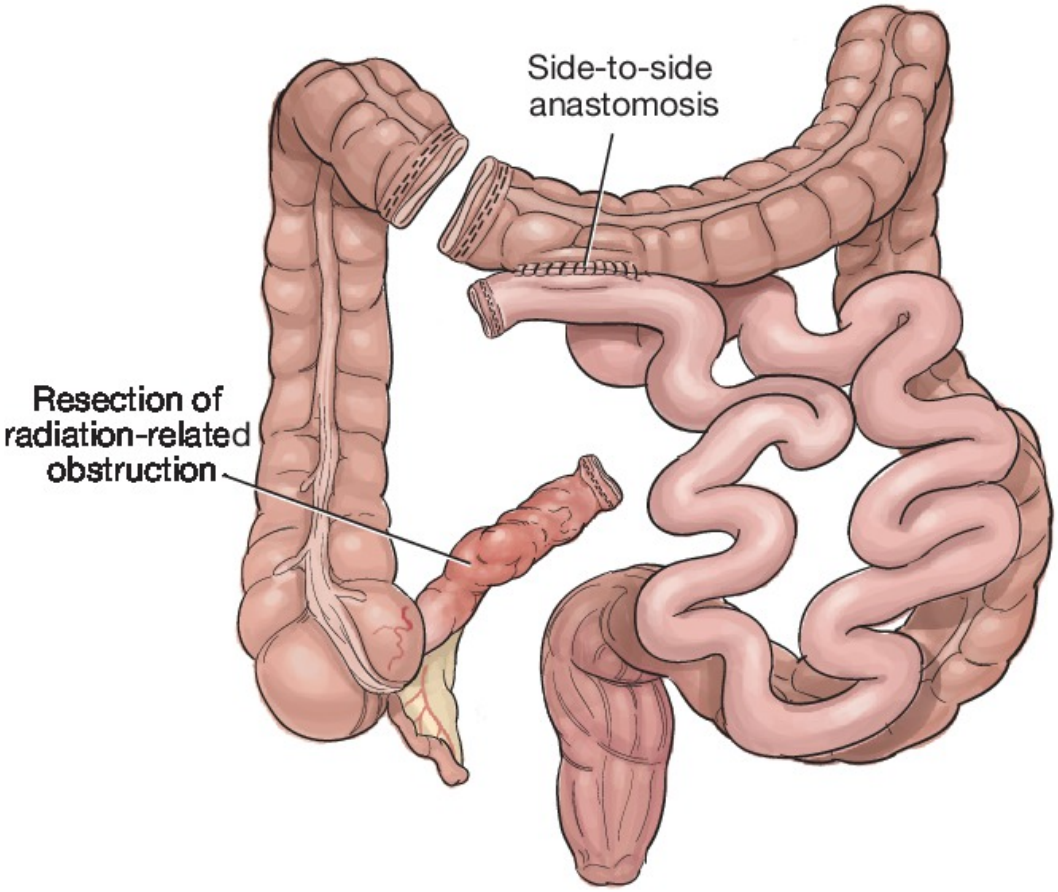



**FIGURE 38.12** Resection of obstructed, damaged bowel with anastomosis of small bowel to unirradiated transverse colon.

The surgical approach to a patient with radiation-induced small bowel obstruction must be individualized. If the overall condition of the patient is poor or there is recurrent disease, the most expeditious and least complicated procedure (ie, simple bypass or ileostomy) should be carried out. If there is potential impending necrosis of the involved bowel, multiple injuries to the bowel as a result of dissection, or the involved bowel is a simple loop that is not densely

adherent, resection with end-to-end enterocolostomy is preferred. Isolation bypass may still be applicable in some of these cases. Matted loops of bowel in the irradiated pelvis should be left in place if a reasonable length of proximal small bowel can be bypassed to nonirradiated proximal colon. It is preferable to avoid resection, but the bypassed bowel should be diverted from the fecal stream in the event that further necrosis with potential fistula formation should develop.

Colon resection for benign gynecologic disease is infrequent; however, ovarian cancers can encase and partially obstruct the sigmoid or transverse colon. When such disease is surgically resected, the decision for left colon anastomosis is individualized. Radiation-related stricture of the rectosigmoid colon is discussed below.

# Fistula

Common sources of an intestinal fistula include anastomotic failure, occult operative injury, incorporation of bowel into wound closure, inflammatory bowel disease, tumor erosion into adjacent bowel (in case of enterovaginal fistula), radiation necrosis of the bowel wall, and presence of exposed and/or compromised bowel following fascial dehiscence. Most fistulae communicate with the skin and can arise from any portion of the gastrointestinal tract. The reported overall mortality rate is between 5% and 20%, with most deaths resulting from uncontrolled sepsis with and without associated malnutrition. The mortality rate is significantly enhanced in the setting of small bowel fistulae, inflammatory bowel disease, cancer, or previous abdominal radiation.

Enteric fistulae occurring in gynecologic cancer patients reflect a much different population. The majority of patients have active intra-abdominal cancer, prior extensive radiotherapy, or both. Most fistulae develop, at least in part, because of these factors. A large percentage of the fistulae in these patients communicate with the vagina, and the majority arise from the terminal ileum or rectosigmoid colon.

A leaking small bowel anastomosis may form a communication with the abdominal incision or vagina, resulting in an enterocutaneous or enterovaginal fistula, respectively. During the process of fistula formation, intra-abdominal leakage of bowel contents may result in peritonitis or abscess formation and, in some cases, ongoing peritoneal contamination. Uncontrolled sepsis in these patients is the major factor associated with mortality.

More proximal small bowel fistulae cause other types of difficulties and, fortunately, are less commonly seen in the gynecologic cancer patient. Jejunal fistulae have a high output of caustic succus entericus that is corrosive to the skin and results in substantial loss of fluids and electrolytes. For high-output and proximal fistulas, total parenteral nutrition (TPN) may be required. In some cases, however, the distal small bowel may be intubated with a catheter or feeding tube through the fistula and fed distally to allow for nutritional support/supplementation as one gains control of the fistula and await resolution.

Initial management of the patient with a high-output small bowel fistula consists of bowel rest, nasogastric decompression, fluid resuscitation, electrolyte replacement, local management of the fistula output to prevent skin erosion, and control of sepsis. If there is concern of intra-abdominal contamination laparotomy, washout, and drainage may be needed if peritonitis with symptoms such as rigidity, guarding, rebound tenderness is suspected. In the setting of a contained leak, sepsis may resolve with bowel rest and antibiotics but in some cases will require drainage of an abscess and/or prompt proximal diversion. This decision should be based on the patient's response to nonoperative therapy including resolution of leukocytosis, resolution of fevers, improvement in pain, and control of fistula output.

Once sepsis is controlled, spontaneous closure of the fistula is reported to occur in 30%-60% of cases, and nearly all spontaneous closures occur within 4 weeks. After the patient has been initially stabilized, a thorough radiologic evaluation of the fistula and the remaining small and large bowel is undertaken. An early attempt at closure of a postoperative fistula is associated with a low likelihood of success and a high rate of morbidity. The use of octreotide has

been suggested to shorten the interval to spontaneous closure, improve the spontaneous closure rate, and reduce gastrointestinal secretions through the fistula; a meta-analysis of 14 randomized controlled trials supported early use of somatostatin or its analogues to increase the likelihood and rate of fistulae closure. However, there is conflicting literature in this regard, and the use of somatostatin for this purpose is highly variable within and across institutions.

In certain clinical situations, spontaneous closure is unlikely to occur, and indeed, most fistulae in gynecologic cancer patients will not close spontaneously. These situations include intestinal obstruction distal to the fistula, malignancy at the fistula site, fistula location in a previously irradiated field, the presence of a foreign body, epithelialization of the fistula tract, and a fistula related to inflammatory bowel disease. The mnemonic F.R.I.E.N.D.S. is useful to remember factors that prevent fistulae from closing spontaneously: foreign body, radiation, inflammation, epithelialization, neoplasm, distal obstruction, and short (≤2 cm) tract.

In patients with fistula that have not closed spontaneously, operative intervention should be postponed if the patient is doing well. If spontaneous closure has not occurred after 4-5 months of stabilization, then surgery will be eventually required to restore continuity. The decision to operate on a persistent fistula is dependent on several factors, including the patient's remaining life expectancy, nutritional state, and overall medical condition. Less impactful but also of consideration is the patient's tolerance and ability to manage the fistula.

Surgical management of a small bowel fistula must be highly individualized. Occasionally, it is possible to excise the fistula opening from the bowel and close the defect in layers or to resect the involved segment and perform an end-to-end anastomosis (EEA). However, small bowel fistulae to the vagina encountered in gynecologic cancer patients must often be bypassed, leaving the irradiated or tumor-involved adherent loops of bowel in the pelvis. As with the case of obstruction, the proximal uninvolved small bowel is traced as far as possible, avoiding dissection of densely adherent loops from the pelvis. At this point, the small bowel is divided and

anastomosed to a relatively spared portion of the large intestine. This should be a functional EEA so as to completely exclude the fistula from the fecal stream. Mucous fistulae should be utilized whenever the risk of closed loop obstruction exists.

As a consequence of advancing pelvic malignancy or prior extensive pelvic radiotherapy (possibly combined with the effects of prior extensive pelvic surgery), a fistula occasionally develops between the bowel and the bladder. The first concern is to stabilize the patient and control sepsis, which may be more difficult due to involvement of the urinary tract. After short-term stabilization, surgical intervention will be required. For a relatively simple case of small bowel involvement, the bowel loop containing the fistula is resected. Repair of the bladder is individualized. It is less preferable to bypass the fecal stream due to the persistent ill-effects of mucus or partially contaminated drainage into the bladder. Usually, management of a colovesical fistula will require a temporary diverting colostomy. In more complicated cases of fistula development between the bowel and bladder, especially when there is evident involvement of the bladder by radiation necrosis or tumor, bypass, or diversion of both the intestinal and urinary tracts will be necessary. The associated morbidity and mortality in such patients are expectedly high.

The other type of fistula commonly encountered in gynecologic patients arises from the sigmoid colon or rectum to the vagina. Such a fistula may develop as a complication of surgery (delayed leak from a partial or segmental resection or from an inadvertent injury) or radiation therapy. A postmenopausal woman without cancer presenting with a colovaginal fistula most likely has ruptured diverticulitis. Women may develop an intestinal fistula to the vagina because of inflammatory bowel disease, or as a consequence of advanced colorectal cancer, although the latter is uncommon. In gynecologic cancer patients, a colovaginal fistula may occur due to malignancy, because of distal obstruction. A large percentage of these cases arise due to radiation injury or a combination of factors. After short-term stabilization, a diverting loop or end (if permanent) colostomy is performed.

# Radiation Injury

Severe proctosigmoiditis develops in a small percentage of patients following pelvic radiotherapy for gynecologic cancer. Abdominal cramping, diarrhea, and/or bleeding may result. With cessation of radiation and medical management, some of these symptoms improve over time. If left unattended, however, the injury may progress to perforation or a fistula. The area of injury may be mapped out with the use of contrast studies through the normal GI tract and fistula or with endoscopy. Resection is performed as indicated and intestinal continuity restored whenever possible. A diverting colostomy is advisable until it is certain that the anastomosis has healed (ie, at least 6 months).

Radiation stricture of the rectosigmoid colon may also develop, causing obstruction and necessitating surgical intervention. The area of involvement should be established preoperatively with radiologic and/or endoscopic studies. When feasible, this portion of the large bowel may be resected and anastomosed. Proximal diversion should be strongly considered, and a portion of the omentum should be placed between the anastomosis and prior fistula tract. The colon anastomosis is assessed with barium studies 6 months postoperatively, and if there is no stricture, leak, or fistula, the ostomy is reversed (**FIG. 38.13**).

**FIGURE 38.13** Contrast study of a symptomatic radiated patient, demonstrating stricture of the rectosigmoid colon.

As is the case of severe radiation sigmoiditis, the patient with a radiation-induced colovaginal fistula can sometimes undergo

resection and colorectal anastomosis in hopes of eventually restoring bowel continuity. Some radiation-induced rectovaginal fistulae can eventually be surgically closed. Boronow et al. described local repair of such fistulae after a period of diversion. Park described resection of the rectum beyond the fistula (and the region of severe radiation damage) with transanal anastomosis of the colon to the anus. Bricker described the technique of folding the rectosigmoid colon over itself to cover the fistula with anastomosis of the colon to the top of the loop.

# Bowel Perforation

Perforated bowel with intraperitoneal leakage is infrequently encountered in benign and gynecologic cancer patients. The complication may develop as a result of radiation-induced necrosis (usually of the terminal ileum or sigmoid colon), leakage from an intestinal anastomosis, occult operative injury, or bowel ischemia related to obstruction. Other causes of spontaneous bowel perforation include ischemic necrosis due to vascular insufficiency, perforated ulcer, volvulus, and advanced inflammatory states. When perforated bowel with intraperitoneal leakage is due to radiation injury, diagnosis is often delayed, and the mortality rate is high.

Surgery is undertaken on an emergent basis. If the perforation is localized and contained with no broader peritoneal contamination, resection or exclusionary bypass of the small bowel may be considered. In general, proximal exteriorization should be carried out. The peritoneal cavity should be thoroughly irrigated with an antibiotic solution. Once the inflammatory reaction of the bowel and peritoneal cavity resolves as evidenced by reestablishment of nutritional balance (noncatabolic state), resolution of acute skin irritation, and resumption of functional state, reestablishment of bowel continuity can be considered.

# Acute Appendicitis

Due to the significant overlap in presenting symptoms, age, and prodromal illness, acute appendicitis in female subjects is one of the

most difficult GI diagnoses to distinguish from gynecologic pathology. Pregnancy, especially in the second and third trimesters, may further confound the diagnosis as the gravid uterus displaces not only the appendix but also the focal point of pain. Delayed diagnosis of appendicitis due to pregnancy is a source of significant added morbidity. Female patients are slightly less likely to develop acute appendicitis than their male counterparts, and these are most often diagnosed in women in their 30s.

The classic presentation consists of three components: periumbilical pain migrating to the right lower quadrant, anorexia, and nausea/vomiting. Most surgeons trained before the use of CT scans for evaluation relied on the presence of fever and/or leukocytosis to establish the diagnosis of appendicitis. Scoring systems have been established that integrate presenting signs and symptoms most predictive of appendicitis and assign risk. These scoring systems are designed to avoid axial imaging in patients with a high probability of acute appendicitis based on clinical presentation alone.

The Alvarado score is the most popular of these scoring systems and takes in to account leukocytosis (2 points), iliac fossa tenderness (2 points), migratory pain, anorexia, nausea/vomiting, rebound pain, and fever (all 1 point). An Alvarado score ≥7 generally supports exploration without need for additional diagnostic studies, while lower scores, especially in diagnostically challenging patient groups (eg, children younger than 3 years, adults older than 60 years, and pregnant women in the second and third trimesters), support further diagnostic imaging such as CT scan. In a review of 71 patients with appendicitis and 167 patients with another diagnosis, CT findings suggesting appendicitis include enlarged appendix (93% sensitive/92% specific), appendiceal wall thickening (66% sensitive/96% specific), periappendiceal fat stranding (87% sensitive/74% specific), and appendiceal wall enhancement (75% sensitive/85% specific).

Ultrasound is similarly useful in establishing the diagnosis with sensitivity, specificity, and positive and negative predictive value as high as 99% in some series. Sonographic findings consistent with appendicitis include appendiceal diameter >6 mm,

noncompressibility, presence of appendicolith, periappendiceal fat changes, or nonvisualization of the appendix (ie, negative finding). In a patient whose diagnosis remains uncertain despite all imaging modalities, early engagement of the general surgery team is recommended. They may recommend serial abdominal examinations or proceed to early surgical exploration.

After surgical management, use of closed suction drains in the setting of perforated or complicated acute appendicitis is recommended for patients in whom there is concern regarding the integrity or durability of the appendiceal stump closure. Studies have shown no difference in outcome when drains were used.

# Ogilvie Syndrome (Colonic Pseudo-obstruction)

Ogilvie syndrome, also known as acute colonic pseudo-obstruction, presents with abdominal distention, nausea, vomiting, and diarrhea. Plain radiographs demonstrate a dilated cecum and right colon (**FIG. 38.14**). Ogilvie syndrome rarely occurs spontaneously and is associated with an underlying medical condition in over 90% of cases. Such conditions may include (in decreasing prevalence) trauma, sepsis, cardiac disease, gynecologic disease, recent abdominopelvic surgery, neurologic conditions, orthopedic surgery, and miscellaneous medical or surgical conditions.

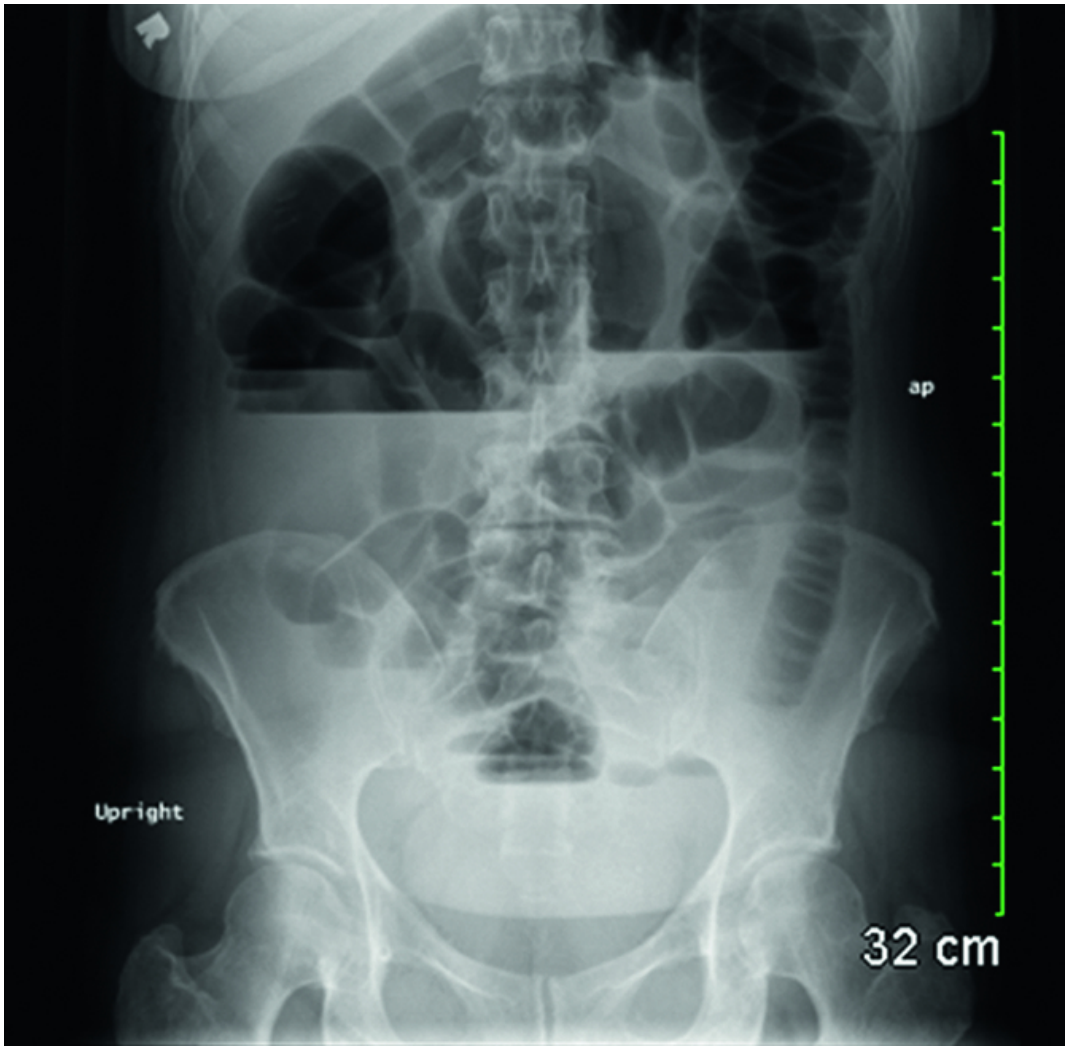



**FIGURE 38.14** Radiograph of a patient with Ogilvie syndrome demonstrating dilation of the entire colon.

Ogilvie syndrome can be differentiated from mechanical bowel obstruction and toxic megacolon by CT study or contrast (Gastrografin) enema. In the absence of mechanical obstruction, initial treatment consists of nonoperative measures including supportive care with intravenous fluids, nothing per mouth, nasogastric tube placement, correction of any electrolyte deficiencies, followed by treatment with neostigmine if there is no resolution after 24-48 hours. Neostigmine, administered at a dose of

2 mg IV, results in rapid resolution (range 3-30 minutes) in 80%-90% of patients. Patients with underlying asthma, recent myocardial infarction, or those who are actively taking beta-blockers should be approached with caution, as severe bradycardia can result with the use of neostigmine. Atropine should be readily available, and patients should receive continuous ECG monitoring during and at least 30 minutes following neostigmine injection.

In patients who fail to respond to nonoperative management, colonic decompression can be achieved either endoscopically or with placement of rectal tube. The need to decompress becomes urgent when colonic diameter approaches 12 cm (beyond which Laplace law predicts a high likelihood of spontaneous perforation). Surgical decompression is rarely required and is reserved for refractory patients at high risk for colonic perforation or for immunocompromised and neutropenic patients in whom colonic perforation would be catastrophic.

# PREOPERATIVE PREPARATION

## Consent

When planning a major gynecologic operation, the likelihood of an intestinal resection and/or an ostomy can be anticipated. Consent for these procedures must be discussed with the patient, especially in regard to creation of a stoma. If the patient adamantly refuses consent for a stoma, the physician must respect the patient's wishes but should make her aware of the possibility that this may compromise the benefits and goals of the operation. In oncologic situations where any otherwise-curative procedure would be precluded by a patient's refusal for stoma, surgical intervention is generally avoided in the absence of perforation, bleeding, or obstruction.

## Stoma Planning

A pelvic surgeon must be able to properly place an intestinal stoma. A working knowledge of stoma management is important to

determine optimal stoma placement. If stoma creation is planned, an enterostomal therapist should mark the stoma site preoperatively. A therapist can provide the patient with information and reassurance, better preparing her for a postoperative stoma management. The preoperative stoma therapy consult also serves to reinforce the inevitability of fecal diversion. Optimal sites for stoma placement are marked, and the surgeon will ultimately make this decision based on intraoperative factors such as mobility of the diverted segment and thickness of the pannus. In some patients (thin, cachectic, short torso), there is no optimal site for stoma placement, and engagement of a stoma therapist to optimize management of the stoma will decrease the need to revise a suboptimal stoma.

Optimal stoma placement is based on several factors. The abdomen is carefully inspected in the supine, sitting, and standing positions, with the surgeon noting the presence of any abdominal wall folds or bony landmarks that could interfere with secure application of the stoma appliance. Ideally, the stoma site is within the boundaries of the rectus muscle, with at least 3 inches of flat skin around the stoma and good visibility for the patient. A lower abdominal stoma (eg, ileostomy or end sigmoid colostomy) is placed somewhere between the umbilicus and the anterior superior iliac spine, whereas an upper abdominal stoma (as for a transverse colostomy) is placed lateral to the umbilicus or somewhere between the umbilicus and the rib cage (**FIG. 38.15**). The stoma must be kept far enough from bony prominences and the belt line to avoid interference with the stoma appliance. Potential stoma sites are marked, and in the operating room prior to prepping the abdomen, the mark can be preserved during abdominal preparation by scratching the skin with a hypodermic needle, or intradermal injection of dye, or other methods.

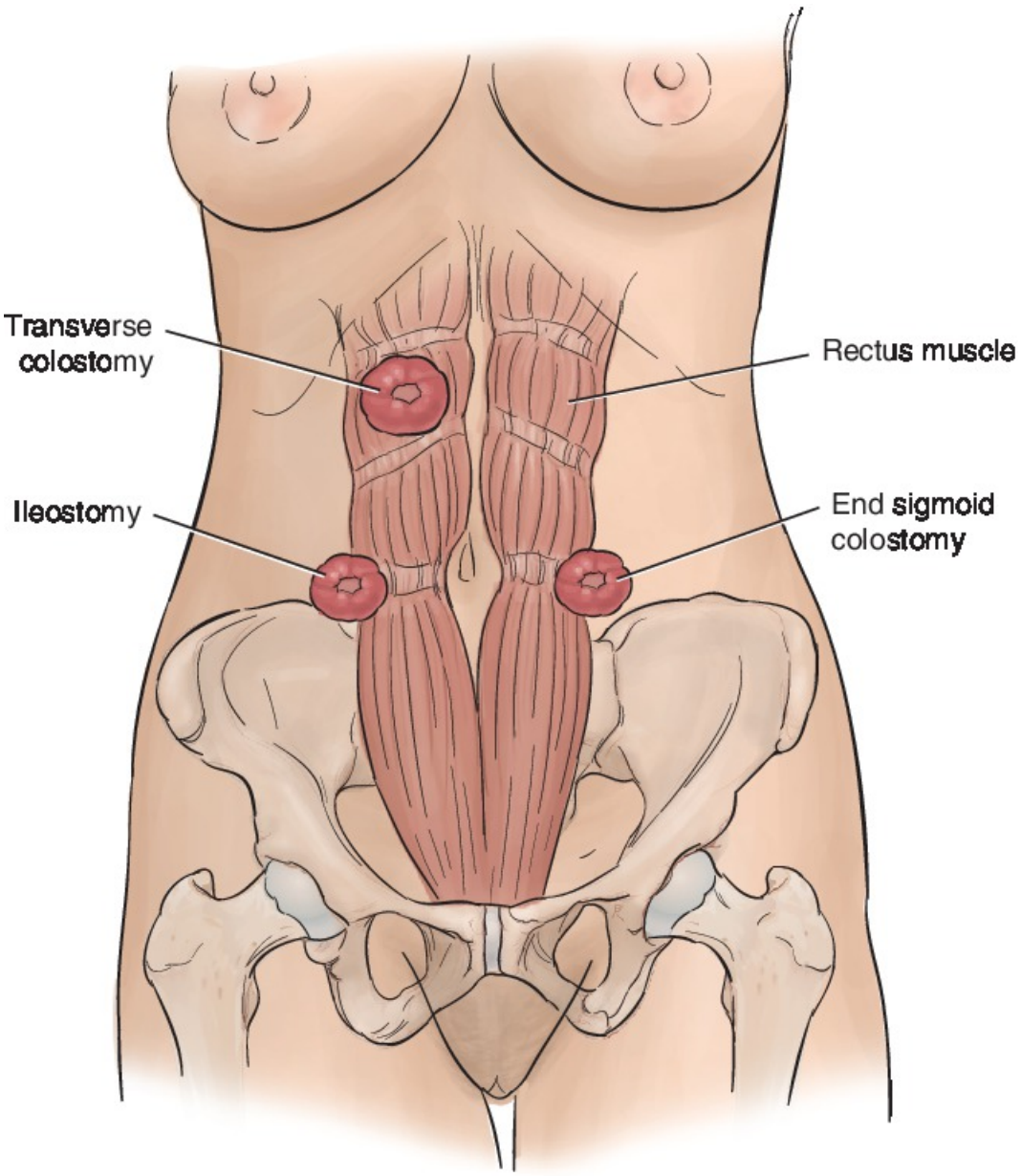



**FIGURE 38.15** Placement of intestinal stomas in the abdominal wall.

# Nutrition

It is important to know the nutritional status of all patients undergoing major abdominal surgery. In the gynecologic population, the nutritional status of most patients is usually good. A few women will

benefit from intensive preoperative nutritional support; many of these women can be identified during initial history and physical examinations. Examples of patients likely to be severely malnourished at presentation include the elderly, patients with advanced ovarian cancer or other advanced malignancy, recent history of significant (>10%) weight loss, prolonged anorexia, generalized weakness and inanition, end-stage liver disease, and bowel obstruction evolving over months. Physical examination findings, including anthropometric measurements, laboratory values, and skin tests, are used to corroborate the clinical suspicion of severe malnutrition.

The decision to intervene preoperatively with nutritional support is based on several factors. Mild to moderately malnourished patients are unlikely to benefit from preoperative nutritional intervention. When surgery is needed on an urgent basis, there will not be adequate time for meaningful preoperative nutritional support. Severely malnourished patients who are to undergo very extensive surgery or are elderly are most likely to benefit from this support. The major complication rate of patients undergoing intestinal surgery may be reduced by intensive preoperative nutritional support.

When the decision is made to supplement or provide complete nutritional support, the surgeon must individualize the use of enteral or parenteral (PPN/TPN) routes. A minimum of 7 days of hyperalimentation has been recommended as the amount to provide benefit. Hospitalized patients with malignant bowel obstruction will benefit most from TPN, while malnourished patients with normal bowel function should be replenished with nasogastric or nasoduodenal supplements that can be administered in the outpatient setting. Nasogastric supplementation has the advantage of bolus feeding every 4-6 hours and does not require a feeding pump. Nasoduodenal feeding minimizes the risk of aspiration, especially in patients with delayed gastric emptying, but requires more expertise and resources in the home environment.

# Bowel Preparation

The routine use of preoperative mechanical bowel preparation for patients undergoing colectomy has come into question in recent years. Surgeons have recognized the implications of potentially unnecessary bowel preparation on perioperative fluid and electrolyte balance as well as patient comfort and compliance.

It is now widely accepted that such preparations provide no advantage regarding anastomotic dehiscence or surgical site infection (SSI) in patients undergoing right colon resection. For a left-sided resection, mechanical bowel prep (MBP) is still commonly used due to the narrow pelvic space and potential of fecal soilage during surgery and subsequen development of pelvic abscess and sepsis. Mechanical bowel preparation in and of itself is most likely not beneficial without the addition of bowel sterilizing oral antibiotics such as neomycin and erythromycin base. Some studies have documented a lower incidence of SSI with utilization of MBP and oral GI antibiotic sterilization prior to left colon surgery, especially when performed through laparotomy. Inherent to this discussion is the assumption that perioperative intravenous antibiotics will be administered per nationally recognized Surgical Quality Improvement Program (SQIP) guidelines.

The author's practice is selective use of MBP with oral antibiotics in patients who are anticipated to undergo multivisceral resection. Patients presenting with colonic obstruction should never undergo preoperative mechanical bowel preparation due to risk of colonic perforation or aspiration. In patients undergoing gynecologic procedures without plans for colon resection, judicious use of preoperative enemas will facilitate operative exposure by decompressing the rectosigmoid colon.

# Patient With Bowel Obstruction

Preoperative preparation of the patient with bowel obstruction begins with optimization of fluid and electrolyte balance and with gastrointestinal decompression. A nasogastric tube is placed and connected to continuous or intermittent low wall suction. Intestinal viability is assessed with axial imaging (eg, pneumatosis intestinalis, portal venous gas) and laboratory assessment of acid-base status.

As previously discussed, bowel obstruction in gynecologic cancer patients tends to occur in the context of certain clinical scenarios. Some patients will be candidates for aggressive surgical management (e.g., adhesion-related cases), while others will not (e.g., advanced recurrent intra-abdominal malignancy). When a patient has a small bowel obstruction thought to be amenable to surgical management and when there is evidence of bowel compromise, surgery should be undertaken promptly after initial correction of hypovolemia. Broad-spectrum antibiotics should also be initiated in these patients. However, most gynecologic cancer patients who develop malignant small bowel obstruction will not be candidates for surgical intervention and should be offered conservative management in the hope that the obstruction will resolve. In cases where neoadjuvant chemotherapy is indicated, hyperalimentation may be used in select cases to nutritionally bridge obstructed patients until the tumor responds in hopes that chemotherapy will decrease the tumor burden and resolve the obstruction.

A “long intestinal tube” (Baker or Miller-Abbott) is rarely employed in the modern era of bowel obstruction management but can be used primarily as an intraluminal postoperative stent in patients undergoing extensive adhesiolysis and bowel resection. Initiation of TPN may also be advisable. After initial stabilization, radiologic studies should be performed to evaluate the possibility of coexisting large bowel obstruction. With large bowel obstruction, surgical intervention will be necessary.

During the initial period of conservative management, if the patient develops any signs or symptoms of compromised bowel, surgery must proceed. If, however, the patient remains stable and the bowel decompresses, there is no urgency to the situation. The patient can be maintained on TPN while allowing 5-10 days for the condition of the bowel to improve and a chance for the obstruction to resolve. If the bowel does not decompress by 48-72 hours, then the patient should proceed to surgery.

# PROCEDURES

This section describes common surgical techniques employed in GI surgery. It is not meant to be an exhaustive review of methods or techniques but rather is designed to convey basic principles and techniques commonly used in the management of the intestinal tract as it relates to gynecologic patients.

# Appendectomy

In surgically naive patients, almost all appendectomies are performed laparoscopically. Appendicitis may be suspected preoperatively or encountered during a diagnostic laparoscopy. The technique for appendectomy is similar whether performed laparoscopically or by open laparotomy. Appendectomy for nonperforated appendicitis with preserved anatomy is a relatively straight-forward operation. An umbilical camera port and two left lower quadrant ancillary ports work well. The patient is placed in deep Trendelenburg position, and the cecum with the appendix is identified and mobilized cephalad. At the appendiceal base, a window is created in the mesoappendix and, as the appendix is retracted to fan out the mesoappendix, it is then divided using energy or stapler to ligate the appendiceal artery. The base of the appendix is then divided after suture ligation or with a stapler, using a load appropriate to the thickness of the tissue. The appendix is placed in an isolation bag and removed through the umbilical port site (**BOX 38.1**; **VIDEO 38.2** and **VIDEO 38.3**).

## BOX 38.1 STEPS IN THE PROCEDURE

### Appendectomy

- Mobilize the appendix and cecum to the extent required.
- Isolate and hemostatically divide the mesoappendix.
- Transect the base of the appendix using suture or stapler.

# Bowel Resection

This operation begins with careful planning for the resection and anastomosis, followed by mobilization of the involved portion or portions of the bowel. The bowel ends to be anastomosed must be healthy, have adequate blood supply, and approximate one another without tension. The blood supply of the small bowel originates from the superior mesenteric artery (SMA) with branches extending throughout the mesentery. In the mesentery, the arterial branches form anastomosing primary and secondary arcades, with the terminal arcades supplying small parallel vessels (vasa recta) that extend to the bowel. Resection of a segment of the small intestine must preserve an adequate arterial arcade, including the vasa recta, to supply the remaining divided ends of the bowel. Small bowel resection in gynecologic cancer patients generally does not require wide resection of the mesentery for the purposes of lymph node harvest such as performed in cases of surgery for GI malignancies. Accordingly, resection of the mesentery should be as conservative as possible to preserve vascular supply to the intestinal remnants.

Following mobilization of the bowel, the remainder of the operative field is isolated from contamination with moist packs or another protective barrier. At the points of planned bowel division, a hemostat is placed through an avascular area of the mesentery immediately under the bowel wall. Along the planned mesenteric resection, the peritoneum on both sides is divided. The mesentery is hemostatically divided. A linear gastrointestinal stapler or noncrushing bowel clamps are placed across the bowel, directed toward the mesentery, and slightly angulated to give a mesenteric advantage. The angulation avoids an ischemic corner of the bowel and creates a slightly larger EEA. The bowel is divided by the GIA stapler or between bowel clamps (**FIG. 38.16**; **BOX 38.2**).

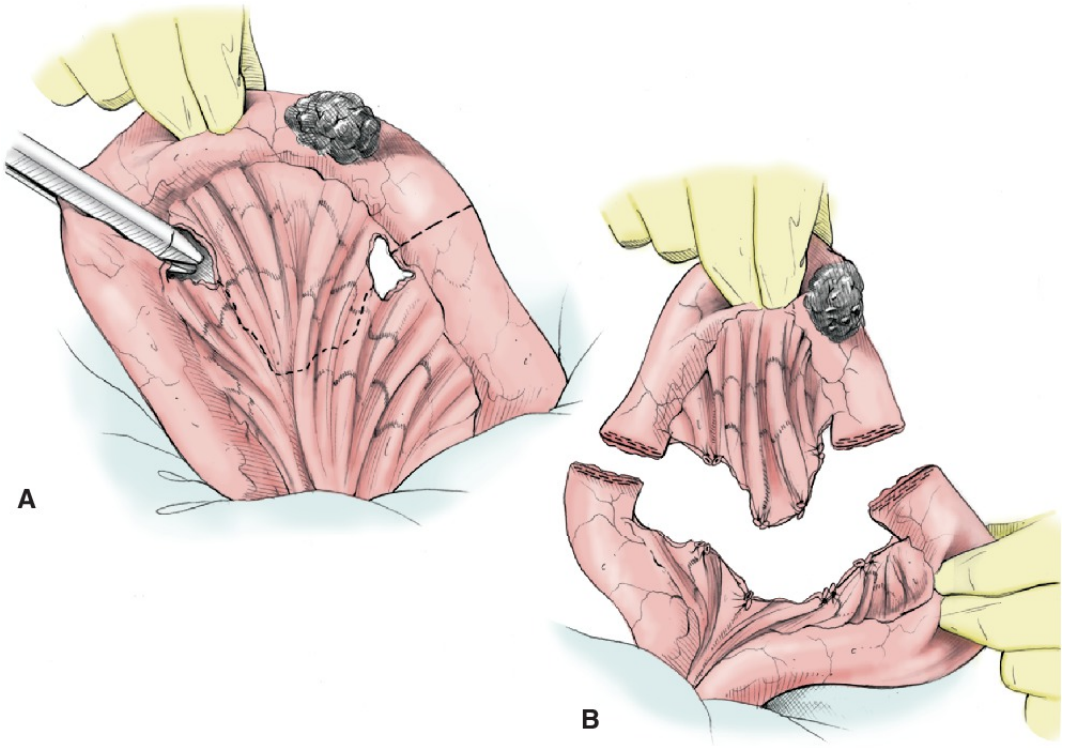



**FIGURE 38.16 A and B.** Planned resection of the small bowel, dividing the intestine with a gastrointestinal stapler.

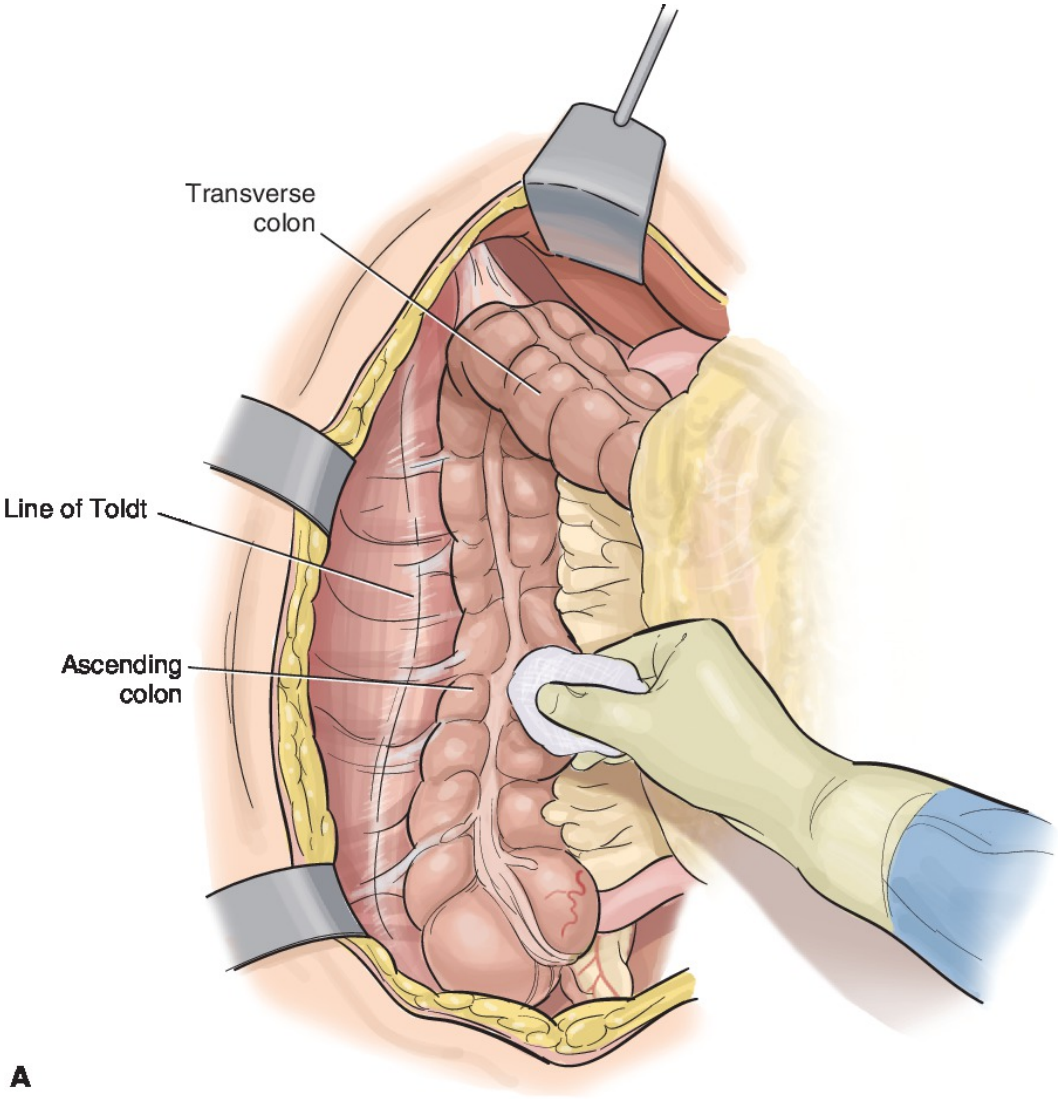
## BOX 38.2 STEPS IN THE PROCEDURE

### Bowel Resection

- Mobilize the segment of the bowel with a view toward a tension-free anastomosis.
- Isolate the bowel from the remainder of the operative field.
- Divide the bowel at the planned sites.
- Resect only mesentery required to clear disease.

Colon resection is carried out utilizing similar principles. Depending on the segment, mobilization of the colon involves incision of the

peritoneal attachments laterally and caudally, separation from the omentum, and division of the hepatic and/or splenic flexures (**FIG. 38.17**). As previously described, the blood supply of the colon is derived from branches of the superior and inferior mesenteric arteries. These branches feed an anastomosing marginal artery, which extends from the ileocecal valve to the sigmoid colon (see **FIGS. 38.3 and 38.4**). From the marginal artery, vasa recta extend to the colon. With resection of the colon, the marginal artery and vasa recta supplying the two remaining ends must be preserved. As with small bowel resection, wide resection of the mesentery with the colon is generally not necessary in gynecologic cancer patients for the purpose of lymph node harvest. The exception is ovarian cancer, which often extensively infiltrates the colon mesentery. If resection is performed for a primary colonic malignancy, a general rule of thumb is to extend the mesenteric resection to the first-named vessel proximal and distal to the site of pathology.


Transverse colon
Line of Toldt
Ascending colon
A

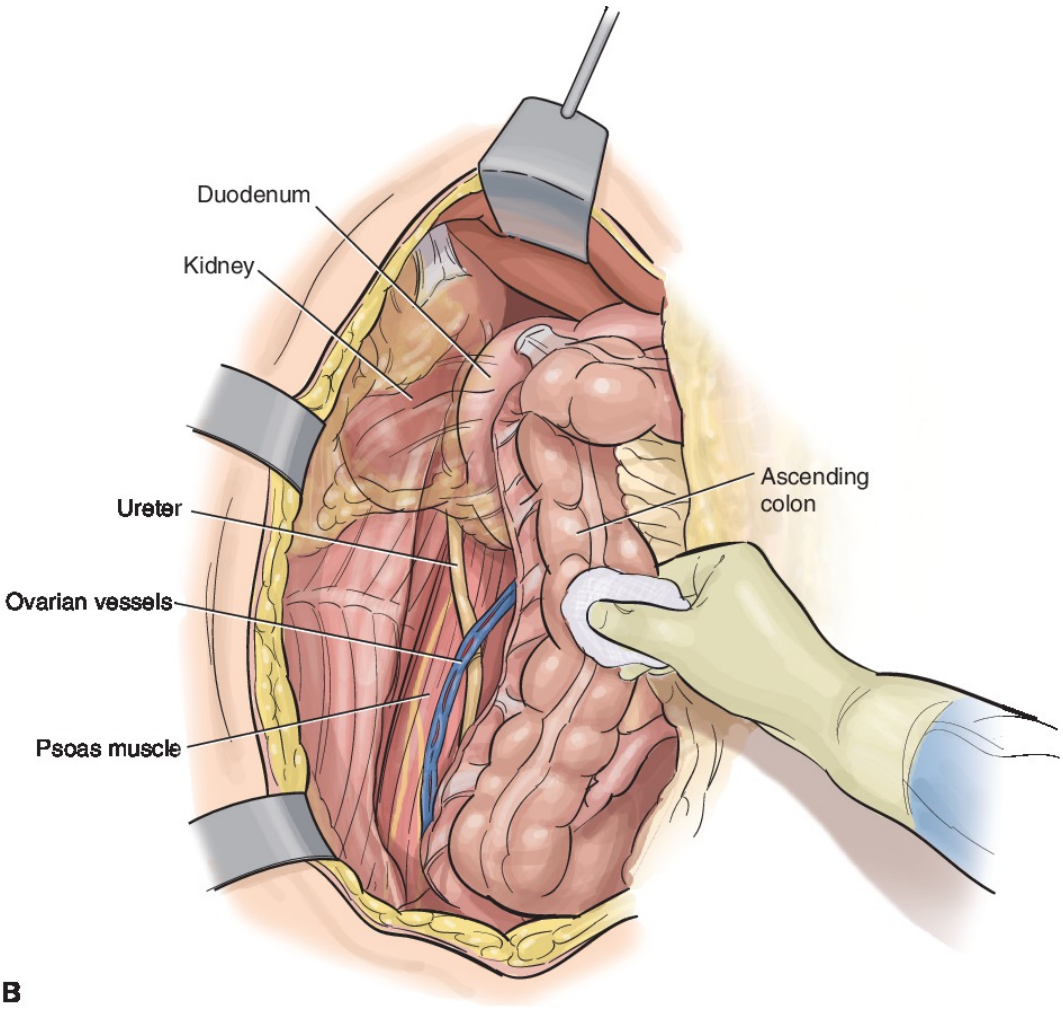



**FIGURE 38.17** **A.** Division of the hepatic flexure. **B.** Together with division of the lateral peritoneal, retroperitoneal (duodenum), and omental attachments, this mobilizes the right and proximal transverse colon.

## Rectosigmoid Colectomy

The rectosigmoid is one of the more common segments of the bowel that the gynecologic oncologist must resect. Removal of this portion of the bowel in gynecologic cancer patients is sometimes performed as an isolated procedure (eg, because of complications from

radiation therapy) but is more often performed as part of an extensive pelvic resection for tumor. In most instances, most of the rectum may be preserved. In other situations, the nature of the disease process or other factors prohibits an anastomosis and a colostomy is performed. Finally, in some cases with extensive tumor involvement, resection of the entire rectum and anus is indicated.

The blood supply to the sigmoid colon and upper rectum is derived from the IMA that branches through the sigmoid mesocolon. The remainder of the anorectum receives blood through the internal iliac (hypogastric) artery. The midrectum receives blood by its first branch, the middle hemorrhoidal artery; the blood reaches the rectum in an anterior-lateral fashion and through the lateral rectal stalks, which are also the major support structures of the rectum to the levator ani. These stalks must be ligated to achieve mobilization of the lower rectum. The region of the rectosigmoid junction was previously thought to have a rather tenuous blood supply. However, arteriographic studies have documented rich collateral circulation with anastomoses between the middle (hypogastric) and superior (IMA) rectal arteries.

Resection of the rectosigmoid colon begins with division of the sigmoid colon at a selected site, followed by complete division of the sigmoid colon mesentery cephalad to the tumor infiltration. The superior rectal artery located at the base of the mesentery is ligated. It is important to safely retract the ureters prior to this. During mobilization of the specimen, the pararectal spaces should be opened carefully and widely deep into the pelvis to the level of the levator muscles. Further mobilization is achieved by incision of the posterior pelvic peritoneum from the points of the completed mesenteric dissection anteriorly to meet the remainder of the pelvic dissection (often dictated by peritoneal tumor extent). The rectum is carefully freed from the presacral space all the way to the levator muscles if necessary.

When the distal aspect of the dissection has been reached, the pelvic specimen is mobilized such that the only remaining attachment is the rectum. This portion of the rectum should be mobilized for anastomosis prior to resection if possible. At the planned level of transection, the fat around the rectum is cleaned. A

stapler, automatic purse-stringer, or right-angled bowel clamp is placed across the rectum at this level, and transection is completed against the instrument. Immediately following resection, it is our habit to irrigate the pelvis with antibiotic solution, particularly if any stool has spilled. Transanal irrigation of the rectal stump is also performed at this time (**FIG. 38.18**; **BOX 38.3**).

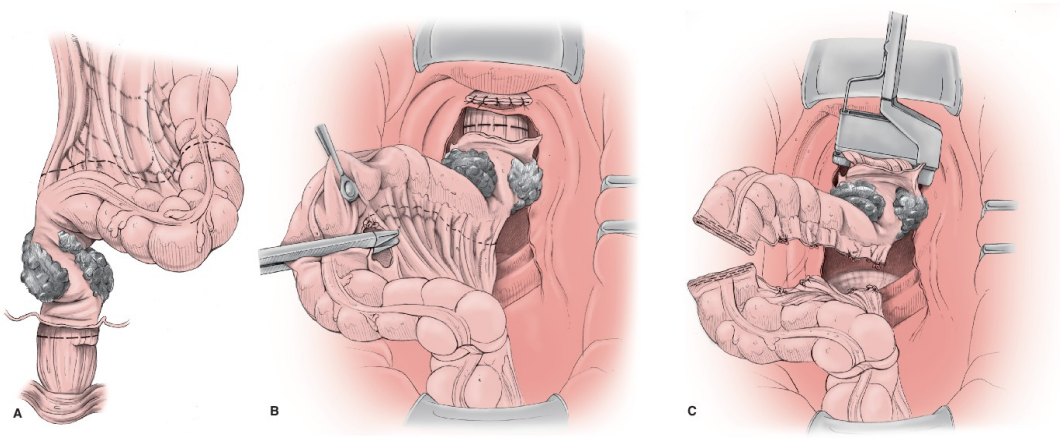



**FIGURE 38.18 A and B.** Division of the sigmoid colon cephalad to the tumor as one of the preliminary steps to extensive pelvic resection. The line of pelvic peritoneal incision is dictated by tumor extent. All of the pelvic peritoneum extending across the infundibulopelvic ligaments and the posterior cul-de-sac is resected *en bloc* with the rectosigmoid colon. **C.** Division of the distal rectum using the linear stapler. The profile of this device facilitates access to deep narrow spaces in the pelvis, requires division of the viscus with a scalpel after it is deployed. and

seals only on the side opposite the transection.

## BOX 38.3 STEPS IN THE PROCEDURE

### Rectosigmoid Colectomy

- Mobilize the left colon including the splenic flexure.
- Divide the sigmoid colon proximal to the pelvic disease.
- Open the pararectal spaces widely and retract the ureters out of harm's way.
- Divide the mesentery and develop the presacral space.
- Divide the peritoneum lateral to the disease process, which will extend through the gonadal vessels and round ligaments and then extend to the reflection of the bladder.
- Additional dissection and mobilization of the rectosigmoid is performed in concert with the remainder of the pelvic dissection.
- Dissection and mobilization continue until the only remaining attachment is the rectum.
- The rectum is additionally mobilized (in anticipation of anastomosis), cleaned of excess fat, and transected.

## Colorectal Anastomosis With a Circular Stapler

Anastomosis of the colon to the rectum is difficult due to the recessed position of the rectum in the pelvis, especially when the remaining rectal stump is short. Anastomosis is greatly facilitated by a circular stapler. If the rectum was transected with a stapler, the

only additional preparation is to clear the fat from the area where the anastomosis will take place.

During surgery, the colon should be mobilized so that the end will reach the rectum without tension. The sigmoid mesentery can be transilluminated to identify additional proximal mesentery that may be divided to further mobilize the colon. However, excessive mobilization from the mesentery will compromise the blood supply. Incising the lateral peritoneal, avascular retroperitoneal, and splenic flexure attachments will achieve additional mobility. Infrequently, the IMA must be divided. The end of the colon is opened and irrigated if necessary. It is the author's habit to irrigate the rectal stump transanally at this point.

Sizers are then used to dilate the anus to facilitate insertion and passage of the EEA stapler. The largest stapler that the rectum will comfortably accommodate should be used. Sequentially larger sizer 25, 29, and 33 mm are inserted per anus to facilitate passage of the circular stapler. A size 28- or 31-mm instrument is used in almost all cases. A purse-string suture with 2-0 monofilament is placed along the edge of the proximal colon. The separated anvil of the stapler is placed into the open end of the colon, and the purse-string is secured around the shaft. The stapler (with completely withdrawn trocar) is then introduced transanally. Directed into the proper position by the abdominal and perineal surgeons working together, the trocar is advanced just above or below the middle of the rectal staple line and the anvil shafts are then connected (**FIG. 38.19A and B**; **BOX 38.4**). The stapler is closed while applying gentle, inward pressure to ensure that the colon stays taught and aligned and does not heap up into the stapling device. The instrument is engaged creating an inverted circular anastomosis with two staggered rows of metal staples, while simultaneously excising the staple line from both ends of bowel. The stapler is then opened and gently removed transanally again with forward pressure to allow complete separation of the anvil from the staple line. The instrument is completely opened and separated, and the two pieces of removed tissue are inspected. There should be two complete mucosal rings. The pelvis is then irrigated with antibiotic solution; a small amount of fluid is left in the pelvis just over the top of the anastomosis. Using an empty large

syringe or proctoscope, the rectum is then filled with air, and the anastomosis is inspected for leaks (ie, bubble test) (**FIG. 38.20**). Any leak is closed with suture, and proximal diversion with loop ileostomy should be considered. Endoscopic inspection of the anastomosis for hemostasis is also recommended by some authors.

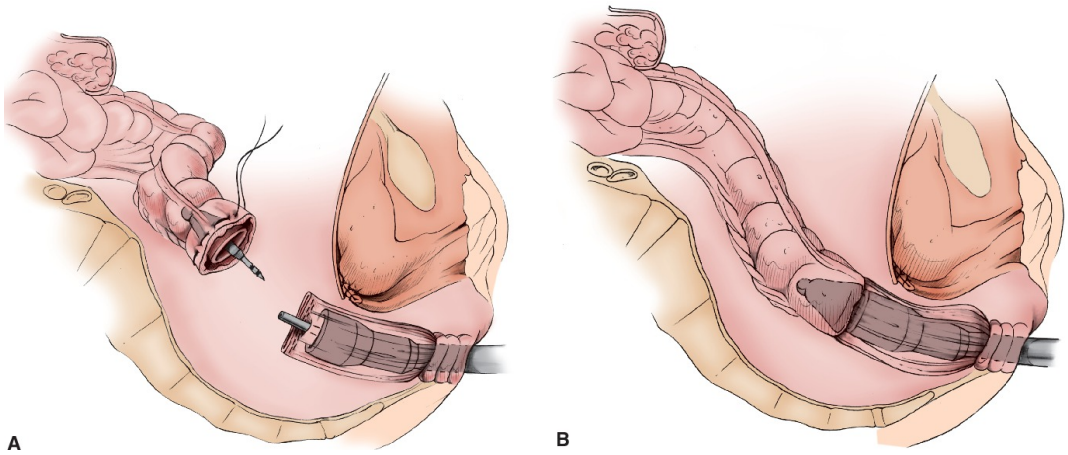



**FIGURE 38.19** End-to-end rectosigmoid staple anastomosis. **A.** A purse-string suture holds the anvil and spike within the sigmoid lumen. The EEA stapler is inserted transanally. Clockwise rotation of the central wing nut advances the sharp trocar to pierce the apex of the rectal stump. In this illustration, the trocar has been removed, and the hollow center shaft of the EEA remains in place. **B.** The spike and hollow center shaft are locked into position. Further rotation of the EEA central wing nut brings the sigmoid and rectum into direct opposition. The stapler is fired to deliver dual circular staple rows as the

knife transects the central tissue core to complete the anastomosis.

## BOX 38.4 STEPS IN THE PROCEDURE

### Colorectal Anastomosis With a Circular Stapler

- Ensure that the ends of the colon and rectum have an excellent blood supply and will approximate without tension.
- Excise GIA staple line from proximal colon and place purse-string suture.
- The separated anvil is placed, and the purse-string is secured.
- The stapler is introduced transanally, and the trocar is advanced through the rectal wall.
- The anvil and stapler are connected, and the instrument is engaged.
- The stapler is opened and removed transanally, and the anastomosis is tested.

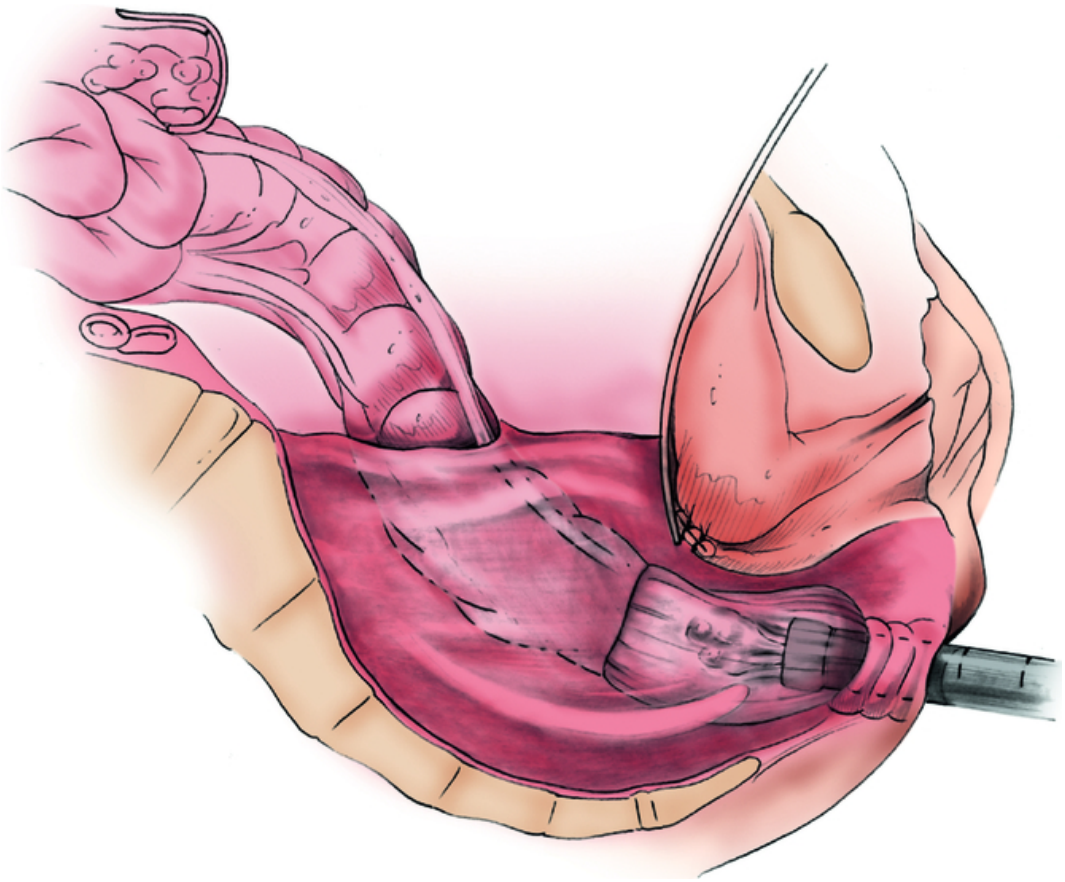


**FIGURE 38.20** Testing the anastomotic integrity. The pelvis is filled with sterile crystalloid. The descending colon is manually occluded as air is insufflated via a rigid sigmoidoscope to create pressure across the anastomosis. Holding the anastomosis under water, it is examined for the air bubbles that would suggest an anastomotic leak.

If a portion of omentum is available, it is transposed into the pelvis and wrapped completely around the anastomosis. Strong consideration is also given to a temporary diverting ("protective") ostomy for such patients. A diverting ostomy is considered for other women who have significant risk factors for an anastomotic leak (eg,

prior pelvic radiation, protein malnutrition, multiple large bowel resections, heavy tobacco use, arterial vascular disease, concerns over the integrity of the anastomosis, or gross contamination of the pelvis) **(FIG. 38.21**).

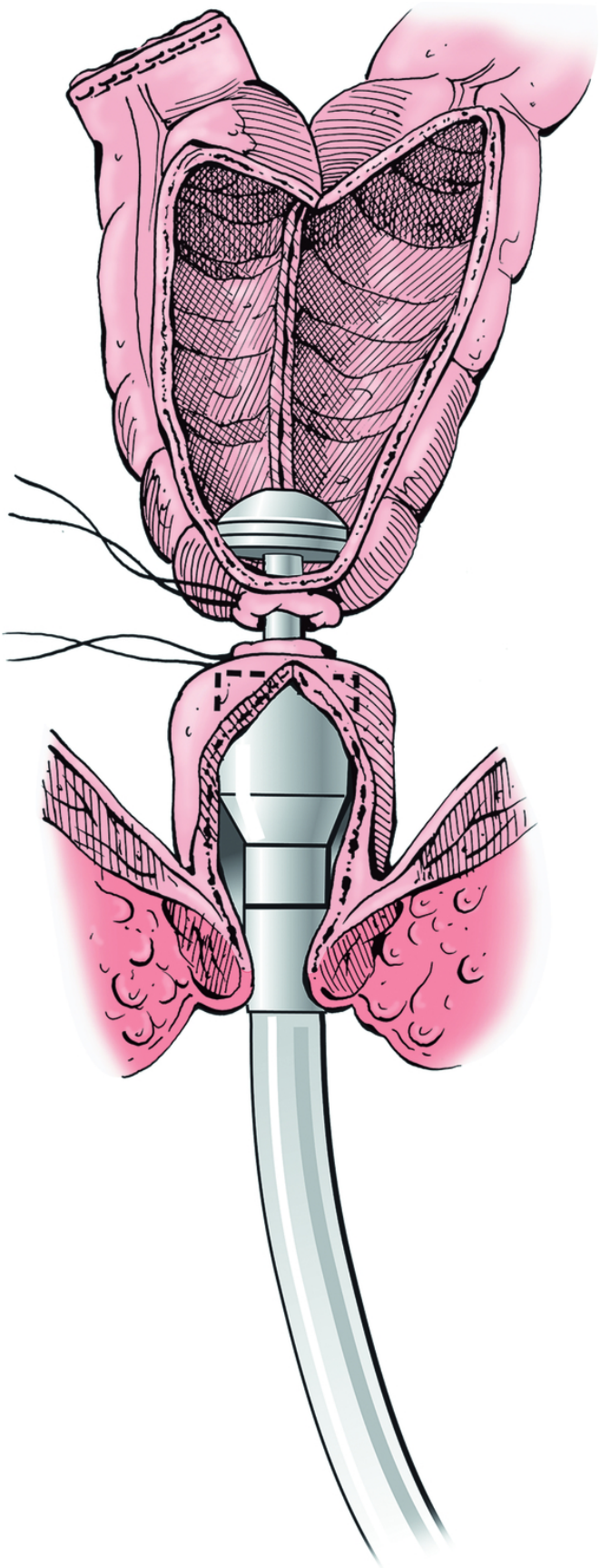


**FIGURE 38.21** Rectal J-pouch coloproctostomy.

## Hand-Sewn Anastomosis

To begin the hand anastomosis, the ends of the bowel are approximated and aligned by an assistant. Using 3-0 silk (or delayed absorbable), an interrupted row of seromuscular stitches is placed 3-4 mm apart and 4-5 mm from the stapled bowel ends or colon with bowel clamps to create a back row. As an alternative to placing staple rows to occlude bowel lumen in preparation for anastomosis, noncrushing bowel clamps can be placed several inches from the bowel ends to similarly prevent spillage of bowel contents during the anastomosis. If bowel clamps were used, these are left in place and used for alignment and manipulation during placement of this back row of sutures. If staples were used, these are also initially left in place. The first and last back row stitches are held long with hemostats for purposes of orientation and alignment.

The clamps on the bowel ends are then removed, or the staple lines are excised, and the open portions of the bowel are emptied. The bowel walls approximated by the posterior row of seromuscular sutures will also have been inverted by these sutures. Using 3-0 Vicryl suture, the full thickness of the two inverted bowel walls is sutured together to form an inner layer (**FIG. 38.22A-C**). The sutures should be 2-3 mm apart using a running or interrupted technique. If a running technique is used, sutures should be placed slightly closer to help prevent stenosis.

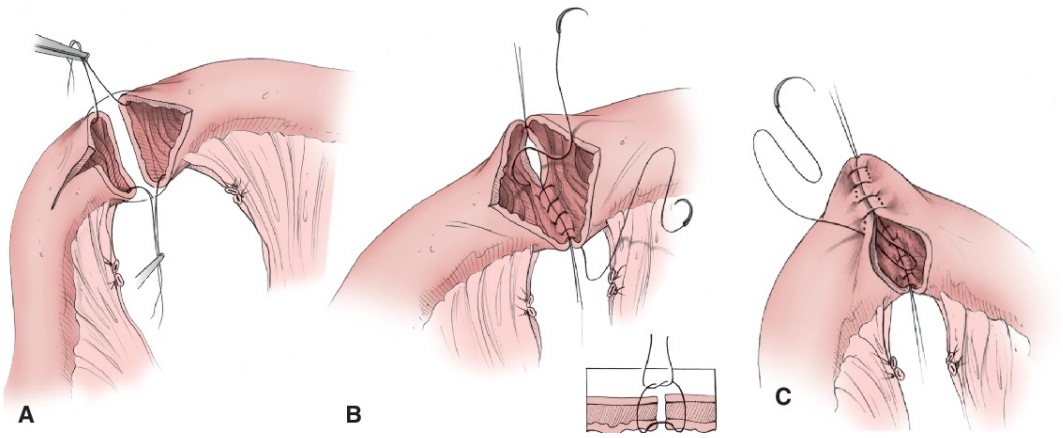



**FIGURE 38.22** End-to-end hand-seven double-layer small bowel anastomosis. **A.** The bowel segments are aligned end to end and secured by stay sutures placed midway between the mesenteric and antimesenteric borders. Each luminal diameter is increased via a linear incision along the antimesenteric border (Cheatle slit). **B.** The inner running layer is started on the mesenteric (posterior) bowel edges. A double-arm needle facilitates bidirectional sewing as the closure continues around the corners onto the antimesenteric (anterior) edges. **Inset:** Conventional inner layer inverting technique. **C.** The anterior inner layer is completed with a continuous over-and-over or Connell suture (as shown).

The anastomosis proceeds by continuing the inner layer until it is completed. As the inner suture line continues beyond the inverted posterior row, it is desirable to continue to invert the bowel edges into the lumen, while at the same time suturing through all layers.

With a running technique, this is best accomplished using Connell stitches (suture placed in parallel bites to incision penetrating submucosal tissue and not lumen) as follows: using an interrupted technique, the edges may be inverted by taking a slightly larger bite of the bowel wall relative to a small bite of mucosa. The outer layer of interrupted Lembert sutures is then completed; a carefully performed single layer is acceptable as well. The occluding bowel clamps are then removed, and the anastomosis is palpated for adequate luminal patency. Finally, the mesenteric defect is closed, avoiding injury or ligation of blood vessels. A hand-sewn anastomosis is shown in **FIGURE 38.23A** and **B**, **BOX 38.5**, and **VIDEO 38.4**.

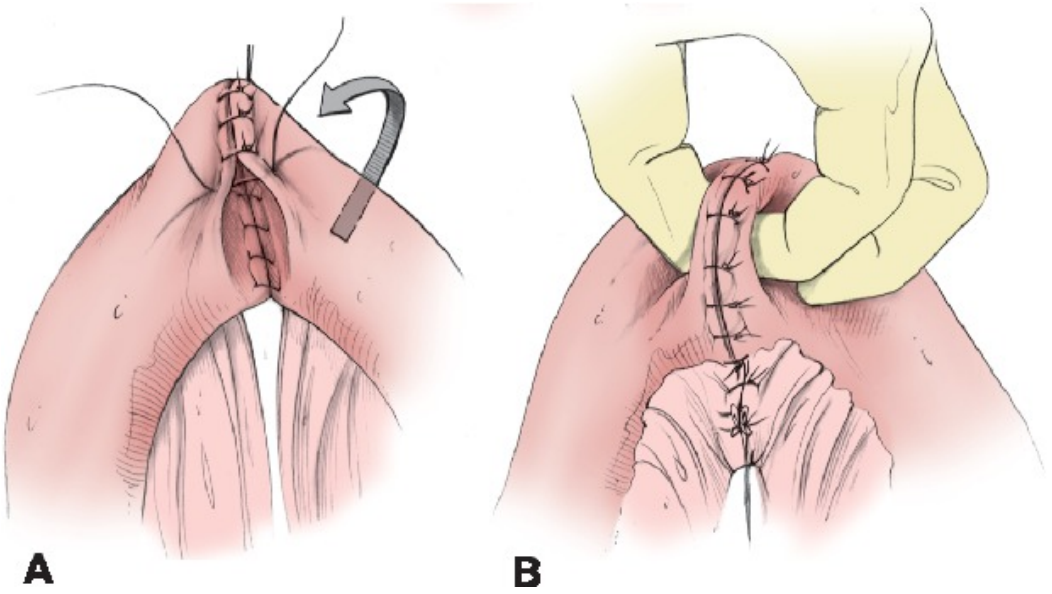



**FIGURE 38.23** **A.** The bowel is rotated 180° to expose the posterior wall. Interrupted seromuscular 3-0 silk sutures are placed to finish the posterior outer layer. **B.** The bowel is rotated back into its normal alignment, and the anterior outer layer is closed with interrupted silk sutures. The mesenteric defect

is reapproximated, and the adequacy of the lumen is assessed.

## BOX 38.5 STEPS IN THE PROCEDURE

### Open Hand-Sewn Anastomosis

- The two ends of the bowel are aligned with a back row of interrupted 3-0 seromuscular silk sutures.
- Bowel clamps are placed to minimize contamination by bowel contents.
- The clamps or staple lines on the bowel ends are removed.
- Using 3-0 chromic or delayed absorbable suture, a full-thickness inverting anastomosis is created. Interrupted and running techniques are both acceptable.
- The occluding bowel clamps are removed.
- The outer layer of interrupted silk Lembert sutures is then completed.
- A carefully performed single layer anastomosis is acceptable as well.
- The anastomosis is palpated for adequacy.
- The mesenteric defect is closed, avoiding injury or ligation of blood vessels.

## Anastomosis With a Linear Stapler (Side to Side)

Stapled bowel anastomoses are comparable to that of hand-sewn anastomosis with regard to leak and anastomotic stricture rate. Advantages to using staplers include speed, consistency in technique, and relative simplicity. Disadvantages include cost, need

to mobilize more bowel, and creation of more nonfunctional bowel in borderline patients with short gut. Perhaps the greatest disadvantage of the stapled anastomosis is the perpetuation of a generation of abdominal surgeons who are at best uncomfortable and at worse unfamiliar with traditional hand-sewn techniques, which are the only option in certain clinical situations such as anastomoses near the ligament of Treitz, the ileocecal valve, or between the right colon and distal sigmoid colon and rectum. This technique is easily adaptable to end-to-side and side-to-side anastomoses. The stapler simultaneously places two or three (depending on the load chosen) rows of staggered staples side by side and cuts between them.

To begin the anastomosis, the two ends of bowel are aligned in a side-to-side fashion. Along the borders of the mesenteries, the bowel walls are aligned with interrupted 3-0 silk seromuscular sutures for a length of ~6-10 cm. The suture at the end of the bowel is held with a hemostat for the purpose of orientation. Using this approach, occluding clamps are also placed to reduce contamination. If the resection was done with staplers, antimesenteric corners of the staple lines should be excised to accommodate the forks of the stapler (**FIG. 38.24A**). One fork is inserted fully into each lumen; care must be taken to ensure that the bowel ends are aligned evenly and that their mesenteries are clear (**FIG. 38.24B** and **C**). The instrument is then carefully closed and fired, creating an anastomosis. Before opening the instrument, a few seromuscular stitches may be placed to imbricate and take tension off the anterior row of staples. The stapler is then disarticulated *in situ* and used as a retractor to inspect staple line for bleeding (**FIG. 38.24D**). Bleeding sites may be oversewn or carefully cauterized. The remaining common channel is then closed with sutures or a stapler (**FIG. 38.24E** and **F**). The additional staple line may also be imbricated with Lembert sutures as is the author's preference. The occluding bowel clamps are removed, and the anastomosis is palpated for adequacy. A side-to-side anastomosis is performed in a similar manner (**BOX 38.6**).

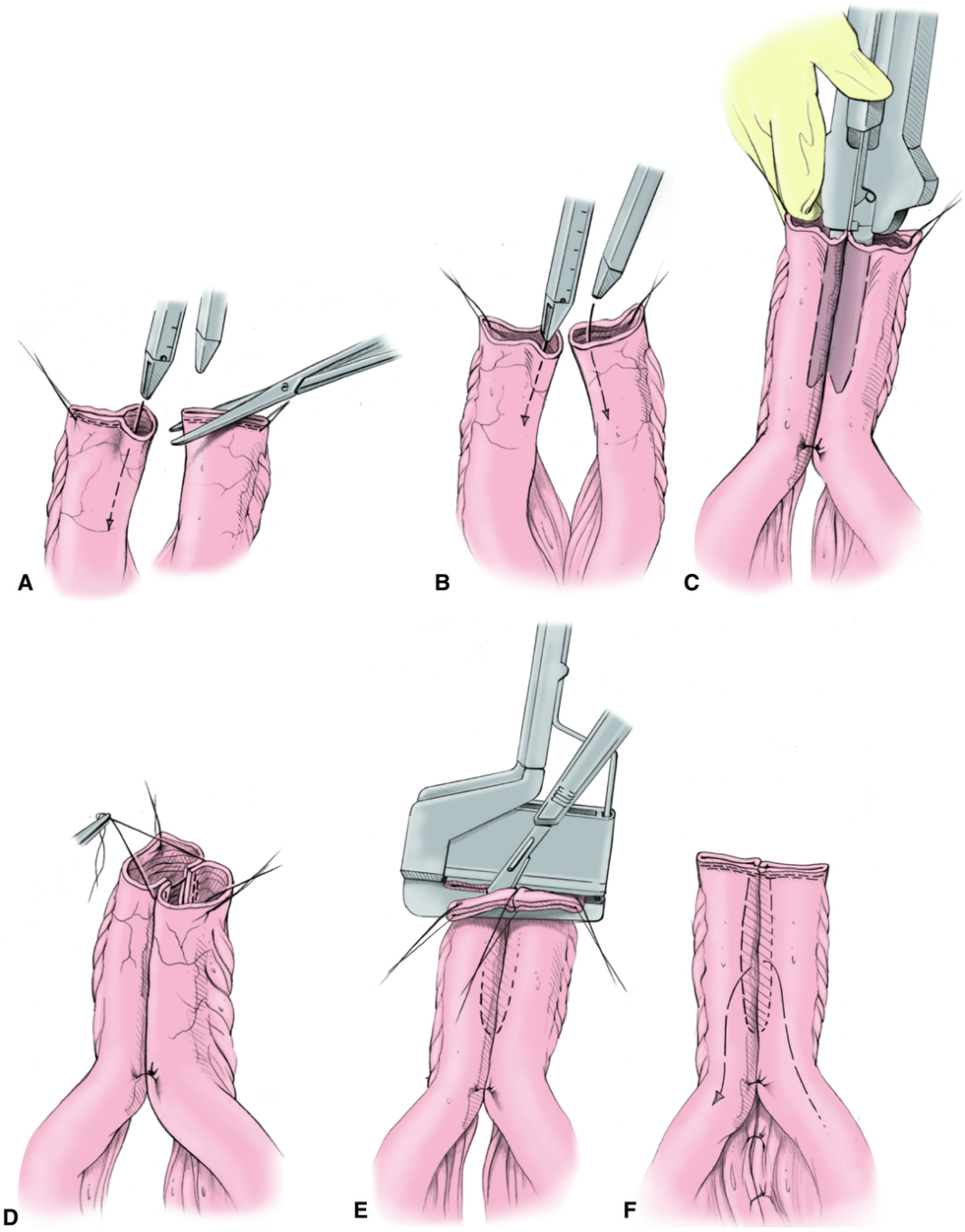



**FIGURE 38.24** **A.** Preparing for an end-to-end stapled anastomosis. The two ends of the bowel are aligned with sutures, and a corner of each staple line is excised in order to accommodate a fork of the stapler. **B.** A fork

of the stapler is placed into each end of the aligned bowel. **C.** The two forks of the stapler are aligned and closed, avoiding inclusion of the mesentery. The stapler is fired, and additional front row seromuscular sutures may be placed. **D.** The stapler is removed. After inspection of the internal anastomosis for patency and hemostasis, the open end (which accommodated the stapler and is now common) is held closed and aligned with sutures or a series of Allis clamps. **E and F.** A stapler is placed underneath the Allis clamps across the common opening and fired. This closes the opening and completes the anastomosis.

## BOX 38.6 STEPS IN THE PROCEDURE

### Anastomosis With a Linear Stapler

- Along the borders of the mesenteries, the bowel walls are aligned with interrupted 3-0 silk seromuscular sutures for a length of ~6-10 cm.
- As before, occluding clamps are placed to reduce contamination.
- Antimesenteric corners of the staple lines are excised to accommodate the forks of the stapler.
- One fork is inserted fully into each lumen; care is taken to ensure that the bowel ends are aligned evenly and that their

mesenteries are clear.

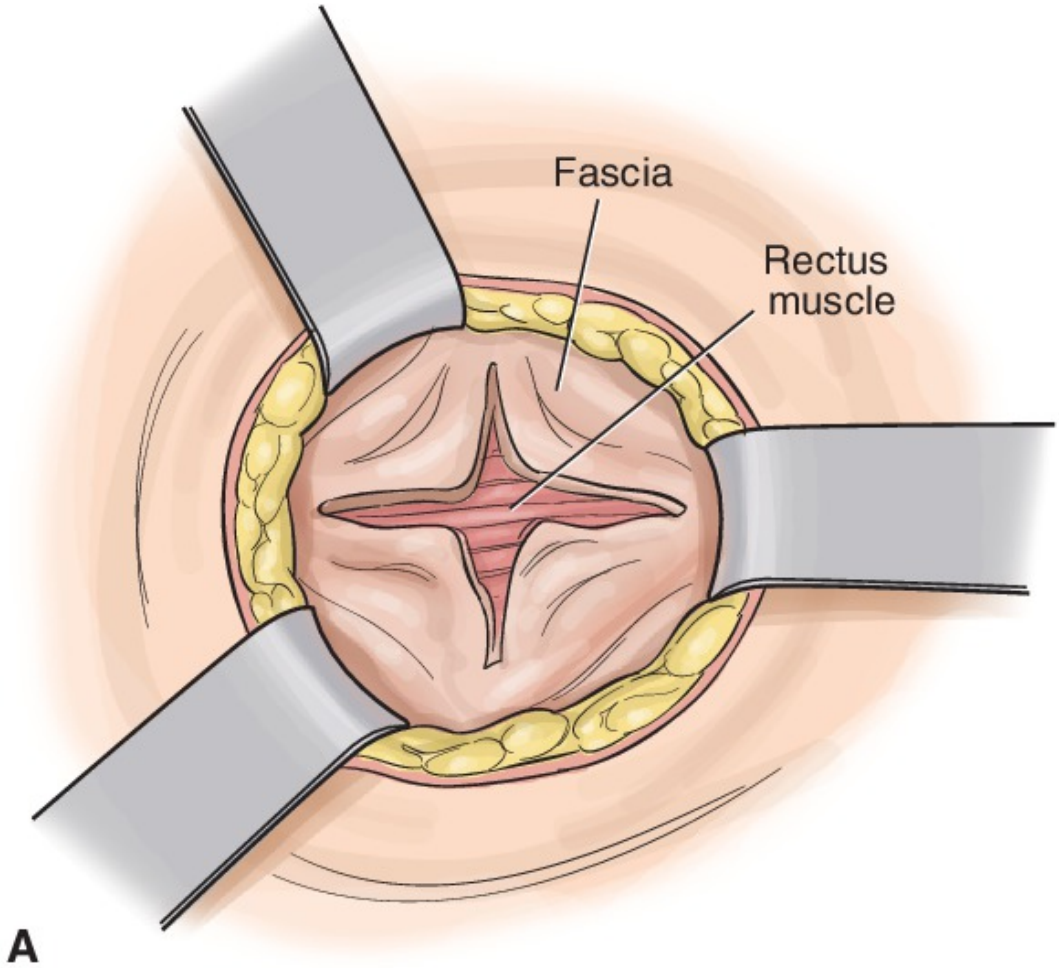
- The instrument is then closed and fired, creating an anastomosis.
- Before opening the instrument, a few seromuscular stitches may be placed to imbricate and take tension off the anterior row of staples.
- The stapler is then opened and removed, and the staple line is inspected for bleeding.
- The remaining common opening is then closed with sutures or a stapler.
- The additional staple line may also be imbricated with Lembert sutures.
- The occluding bowel clamps are removed, and the anastomosis is palpated for adequacy.
- A side-to-side anastomosis is performed in a similar manner.

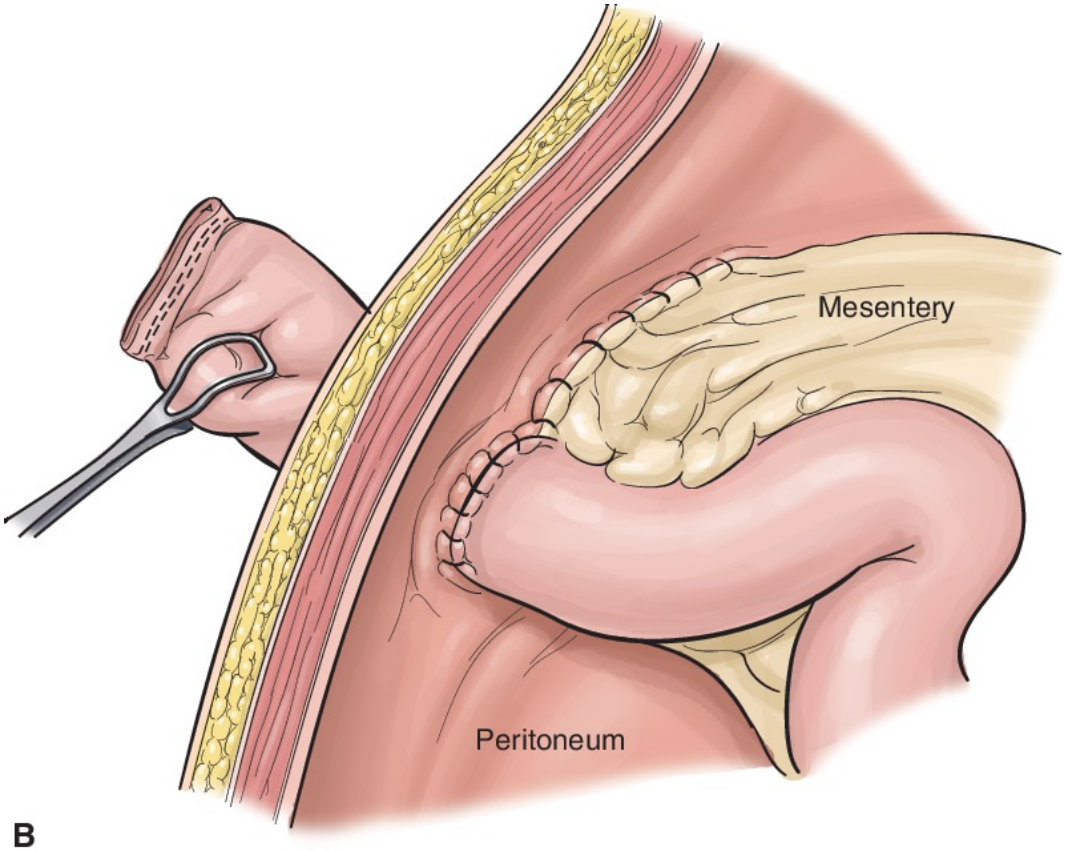
# Ileostomy

Depending on the circumstances, an ileostomy may be formed from the end of the transected functional ileum (end ileostomy) or from a loop of ileum. The main role of a loop ileostomy is temporary diversion. If performed as an isolated procedure, an ileostomy can sometimes be created through a small right lower quadrant incision or with laparoscopy.

The technique of end ileostomy is straightforward. The mesentery is carefully mobilized so that the end of the ileum may be brought through the right lower quadrant with adequate blood supply. A site is chosen and a circular, quarter-sized segment of skin is excised. The fascia is exposed, and a cruciate incision is made (**FIG. 38.25A**), followed by extension of the incision into the peritoneal cavity. The entire opening should be large enough to accommodate the end of the ileum without compromising the mesentery/blood supply. The ileum is brought through the opening with a Babcock clamp until it extends ~6 cm above the skin without tension (**FIG.**

38.25B). The bowel wall is then secured to the peritoneum with interrupted 2-0 silk sutures. The ileostomy is matured after closing the abdomen and isolating the abdominal incision with an occlusive dressing to avoid soilage (FIG. 38.25C). The maturation should create a protruding nipplelike stoma (as described by Brooke), which directs the liquid bowel contents directly into the appliance bag. If circumstances dictate that the transected end of the defunctionalized ileum should be exteriorized as a mucous fistula, this may be brought out at a separate site as a small, flat stoma or with the functional end as a modified loop ileostomy.






**B**

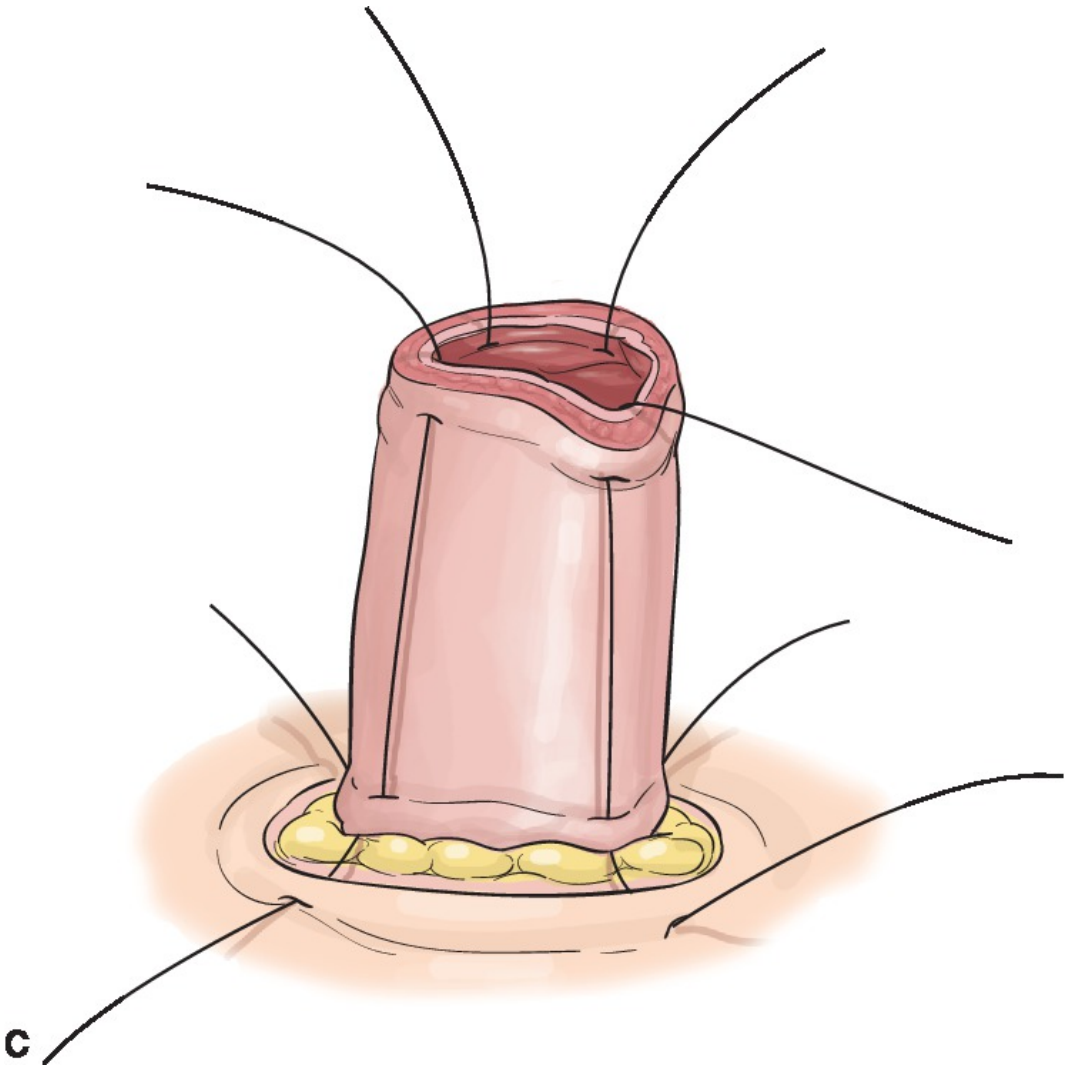
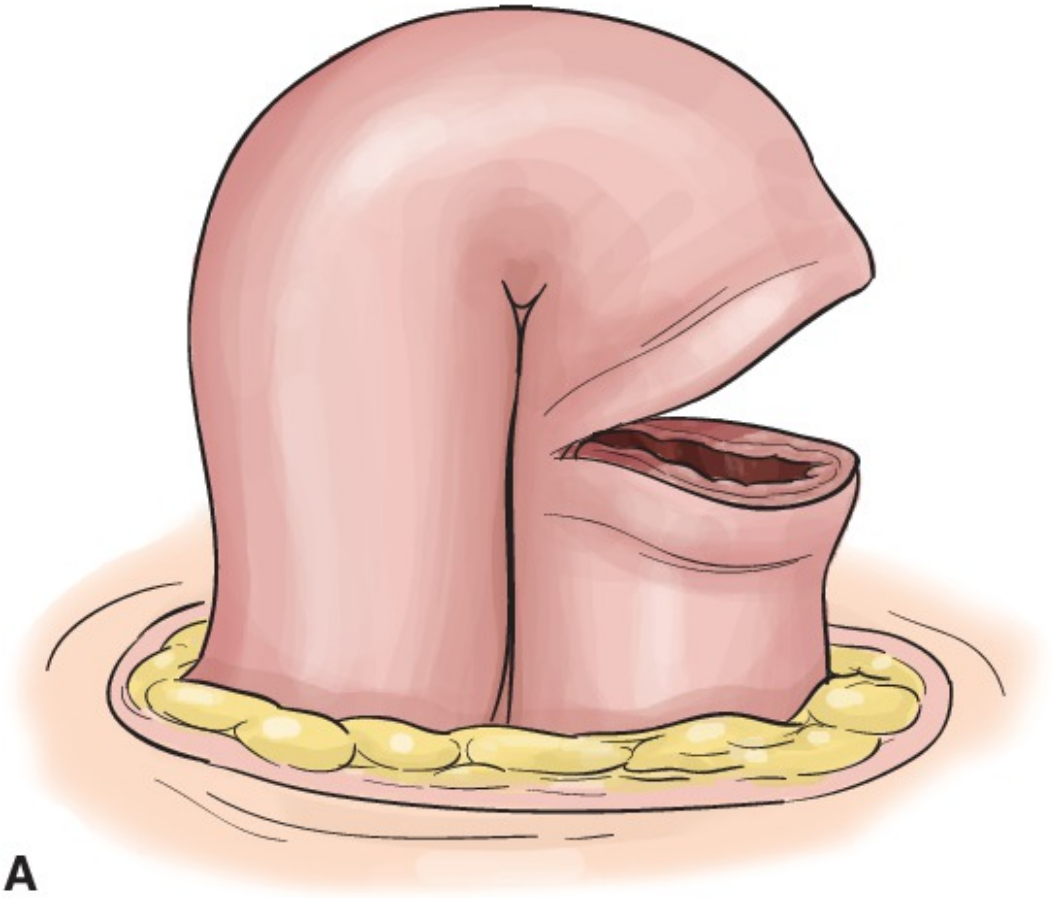


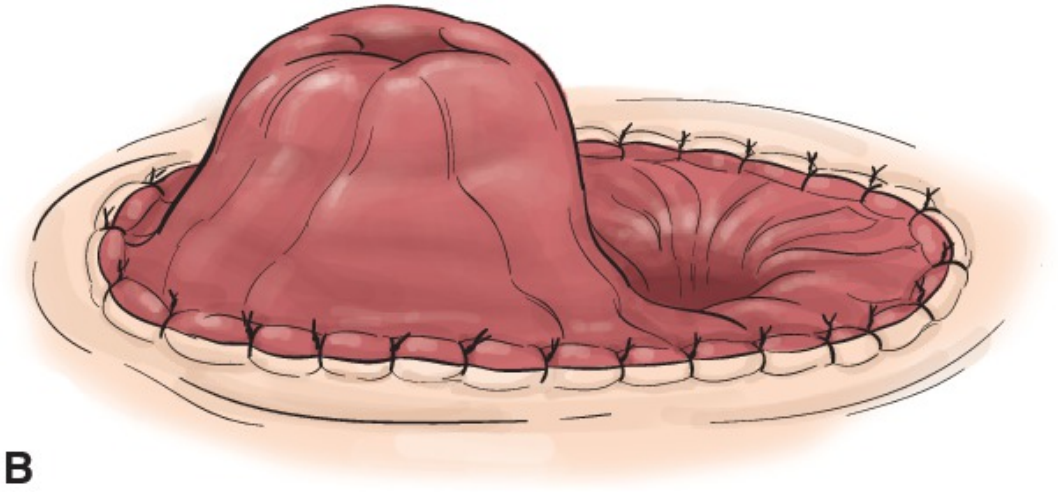

**FIGURE 38.25** **A.** Circular skin and cruciate fascial incisions made for the ileostomy. **B.** Stapled end of the ileum delivered through the ostomy incision. **C.** Creation of the protruding, nipplelike ileostomy stoma.

A loop ileostomy is brought through a similar opening in the right lower quadrant of the abdominal wall. The loop is delivered with a Babcock clamp until it protrudes ~5 cm above the skin, at which level it is secured to the fascia with interrupted 2-0 delayed absorbable sutures and to the peritoneum with interrupted 2-0 silk sutures. A

supporting bridge is generally not necessary. After closing the abdomen, the ostomy is matured by making a transverse incision across the efferent limb just above the skin The efferent opening is sutured to the skin with interrupted 2-0 sutures. The functional end is then matured in a protruding fashion in the manner described with the end ileostomy (**FIG. 38.26A** and **B**; **BOX 38.7**).



A



B

**FIGURE 38.26** **A.** Bowel incision for loop ileostomy. Length is maintained on the functional side so that it can be matured as a protruding stoma. **B.** Maturation of the loop ileostomy.

## BOX 38.7 STEPS IN THE PROCEDURE

### Ileostomy

- The mesentery is carefully mobilized so that the end of the ileum may be brought through the right lower quadrant with adequate blood supply.
- A site is chosen and a circular, quarter-sized segment of skin is excised. The fascia is exposed, and a cruciate incision is made, followed by extension of the incision into the peritoneal cavity. The entire opening should be large enough to accommodate the end of the ileum without compromising the mesentery.
- The ileum is brought through the opening with a Babcock clamp until it extends ~6 cm above the skin without tension.

- The bowel wall is then secured to the peritoneum with interrupted 2-0 silk sutures.
- The ileostomy is matured after closing the abdomen and isolating the abdominal incision with an occlusive dressing to avoid soilage. The maturation should create a protruding nipplelike stoma (as described by Brooke), which directs the liquid bowel contents directly into the appliance bag.
- If circumstances dictate that the transected end of the defunctionalized ileum should be exteriorized as a mucous fistula, this may be brought out at a separate site as a small, flat stoma or with the functional end as a modified loop ileostomy.
- A supporting bridge is generally not necessary for a loop ileostomy. The ostomy is matured by making a transverse incision across the efferent limb just above the skin. The efferent opening is sutured to the skin with interrupted 2-0 sutures. The functional end is then matured in a protruding fashion in the manner described with the end ileostomy.

# Colostomy

A colostomy may be formed either from the transected end of the colon (usually sigmoid or end descending) or from a loop of the colon (usually transverse). The main role of a loop colostomy is temporary diversion. Most end colostomies are intended to be permanent. In certain situations, a colostomy may also be performed as an isolated procedure laparoscopically or through a small incision placed over the anticipated location of that part of the colon.

A transverse loop colostomy is brought through a circular incision in the right or left upper quadrant. A mobile portion of the transverse colon is selected, to exit the selected stomal site. To accomplish this, it is occasionally necessary to take down the hepatic and/or splenic flexure. This portion of the colon is separated from the omentum and to a limited extent is cleared of fat. A defect is made in the mesentery and a Penrose drain passed through and held. The loop

of the colon is then delivered through the ostomy incision until it protrudes ~5 cm above the skin. A plastic bar (bridge) is placed through the mesenteric defect across the skin to ensure colostomy elevation and complete diversion of stool (**FIGS. 38.27 and 38.28**).

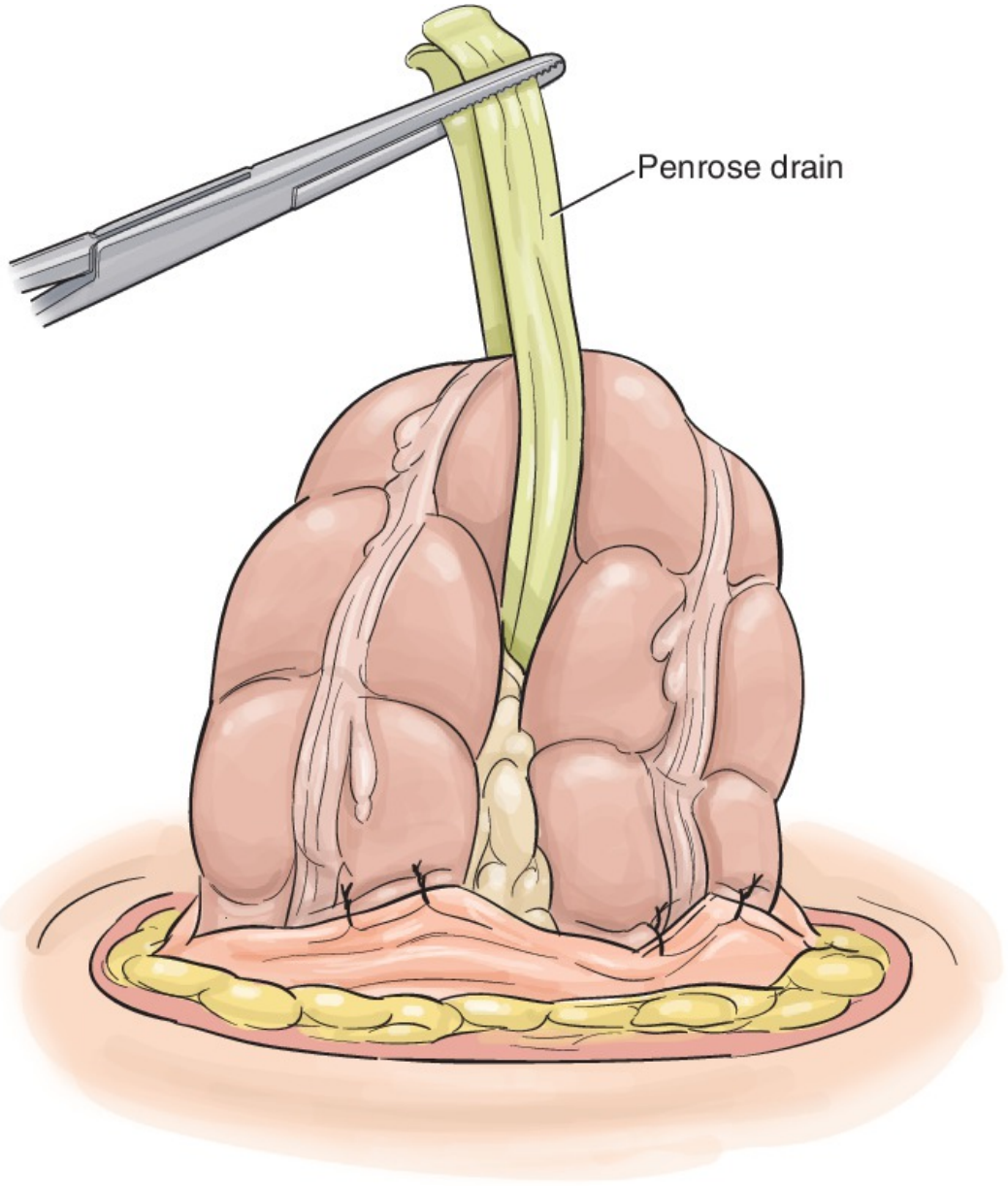



**FIGURE 38.27** Loop of colon delivered through the ostomy incision by a Penrose drain inserted through the mesentery.

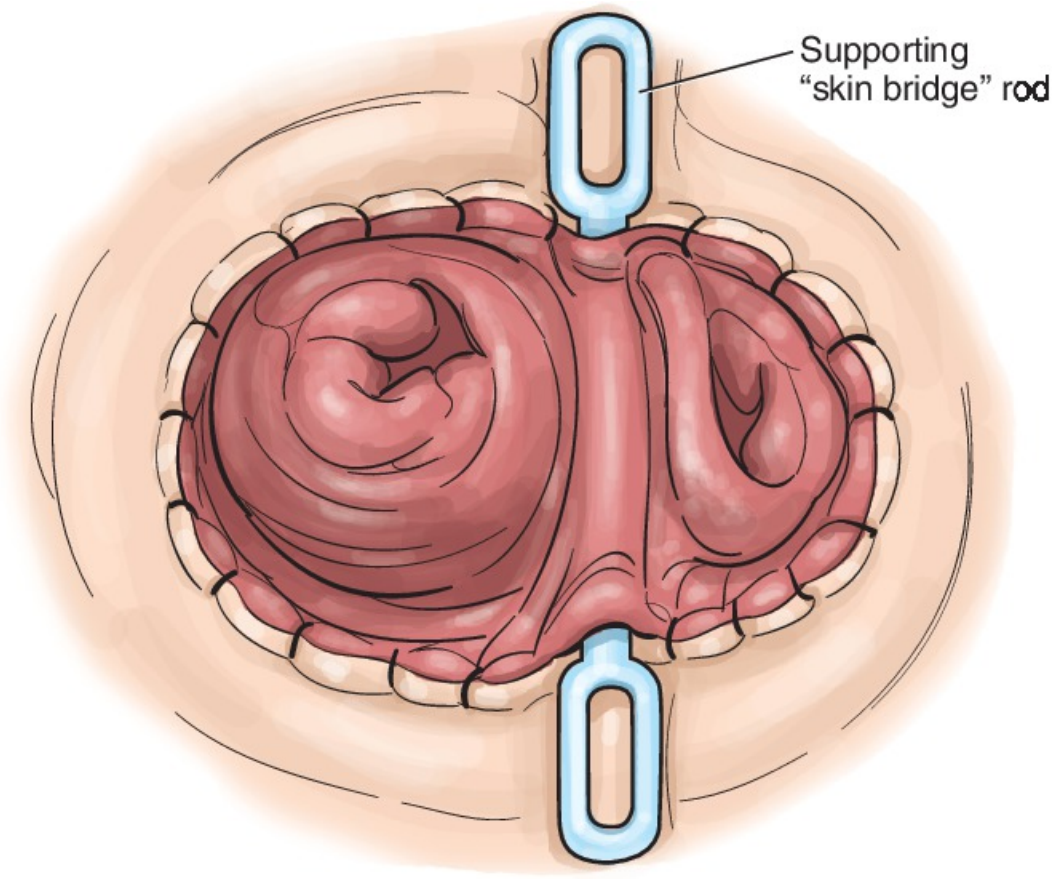



**FIGURE 38.28** The Penrose drain has been replaced by a supporting skin bridge rod. The loop has been partially divided and matured into a colostomy in a manner similar to that described for ileostomy.

When an end sigmoid or descending colostomy is chosen, the colon is placed at a selected site in the left lower quadrant. This portion of the colon is adequately mobilized, and the end is cleared of fat. With a Babcock clamp, the end is then delivered through the ostomy incision until it extends ~3-5 cm above the skin. After closure of the abdomen, the colostomy is matured as described for the end ileostomy. With the expectation of solid stool, the end sigmoid colostomy need only protrude 1-2 cm **BOX 38.8**).

## BOX 38.8 STEPS IN THE PROCEDURE

### Colostomy

- The segment of the colon to be exteriorized is mobilized.
- A site is chosen, and a circular segment of skin is excised.
- For a loop colostomy, the loop of the colon is delivered through the ostomy incision until it protrudes ~5 cm above the skin. A bridge is then placed through the mesenteric defect across the skin.
- For an end colostomy, the end is delivered through the ostomy incision until it extends ~3-5 cm above the skin.
- After closure of the abdomen, the colostomy is matured as described for an ileostomy.

# Loop Ostomy Closure

Takedown of a loop ileostomy or colostomy is performed similarly and can be accomplished through a peristomal incision. An elliptical incision is made, which includes a margin of skin along the stomal edges (**FIG. 38.29**). The loop is then freed to the fascia and separated from the fascial ring. If necessary, a small ring of the fascia may be excised to safely free the loop. The loop is separated from the peritoneum and nearby adhesions until it is freely mobile for closure and replacement into the peritoneal cavity. Depending on the circumstances, the surgeon may elect to simply excise the stomal margin and close the anterior intestinal wall defect transversely, insert a linear stapler through the two ends of the colon and close the transverse colostomy with a stapler or sutures, or resect the stoma and perform an EEA (**BOX 38.9**).

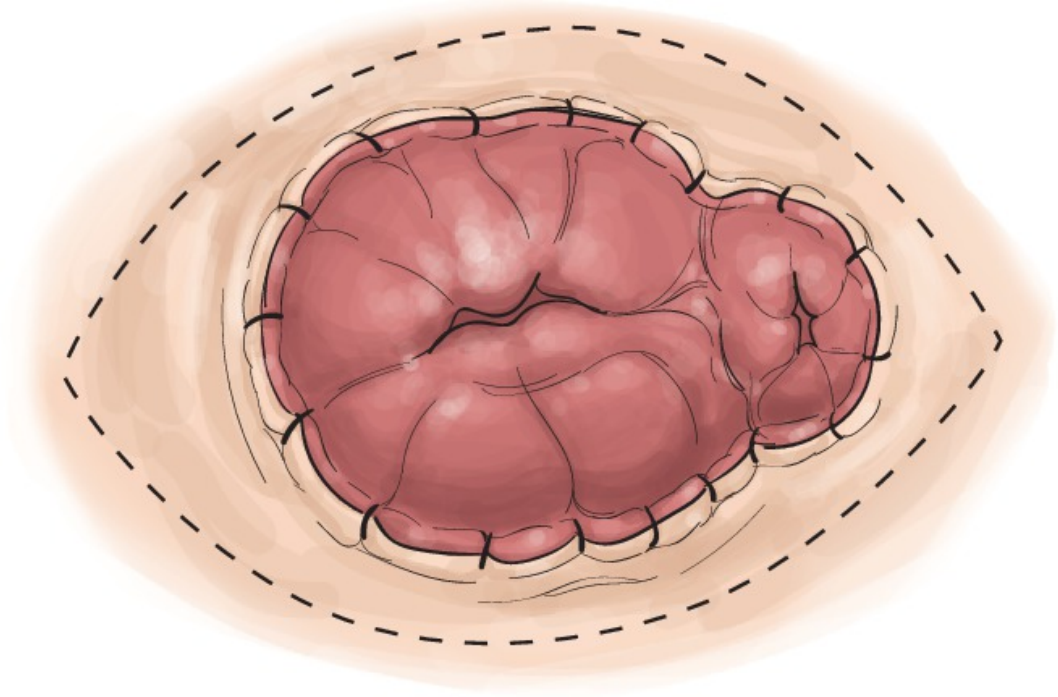


**FIGURE 38.29** Peristomal incision in preparation for closure of a loop colostomy.

## BOX 38.9 STEPS IN THE PROCEDURE

### Loop Ostomy Closure

- An elliptical incision is made, which includes a margin of skin along the stomal edges.
- The loop is then freed to from the fascia, peritoneum, and nearby adhesions until it is freely mobile for closure and replacement into the peritoneal cavity.
- Depending on the circumstances, the surgeon may elect to simply excise the stomal margin and close the anterior intestinal wall defect transversely, insert a linear stapler through the two ends of the colon, or resect the stoma and perform an EEA.

# End Colostomy Takedown

Prior to preparation of the abdomen, the stoma is closed with a purse-string suture or with a running monofilament suture to approximate the skin edges surrounding the stoma in a linear fashion. Alternatively, a large-bore catheter may be placed to occlude the stoma, drain the colon, and aid in identification of the intraperitoneal colon segment. The abdomen is opened through the previous incision, and adhesions are taken down. Some surgeons may elect to perform this laparoscopically. The colostomy is mobilized by making an elliptical incision around the skin and freeing the colon from the fascia and peritoneum. Alternatively, and if length allows, the colon may be transected with a stapler just under the abdominal wall; the stoma is then excised separately. The end is prepared for anastomosis and sized, and the purse-string suture is placed. The rectal stump is mobilized only so far as to define an apex that allows proper placement of the stapler. From this point, the procedure is identical to that of the colorectal anastomosis previously described using the circular stapler, with the exception that the trocar simply penetrates the apex of the rectal stump (**BOX 38.10**).

## BOX 38.10 STEPS IN THE PROCEDURE

### End Colostomy Takedown

- The stoma is closed with a purse-string suture or with a running monofilament suture to approximate the skin edges surrounding the stoma in a linear fashion. Alternatively, a large-bore catheter may be placed to occlude the stoma, drain the colon, and aid in identification of the intraperitoneal colon segment.
- The abdomen is opened through the previous incision, and adhesions are taken down (this may be done laparoscopically).
- The colostomy is mobilized by making an elliptical incision around the skin and freeing the colon from the fascia and peritoneum. Alternatively, and if length allows, the colon may be

transected with a stapler just under the abdominal wall; the stoma is excised separately.

- The end is prepared for anastomosis and sized, and the purse-string suture is placed.
- The rectal stump is mobilized only so far as to define an apex that allows proper placement of the stapler. From this point, the procedure is identical to that of the colorectal anastomosis previously described using the circular stapler, with the exception that the trocar simply penetrates the apex of the rectal stump.

# POSTOPERATIVE CARE AND COMPLICATIONS

Postoperative management of the gastrointestinal surgery patient has evolved in recent years as hospitals and surgeons have embraced the financial and medical advantages of shortened lengths of stay and avoidance of preventable complications. This has been facilitated by global support for and adoption of enhanced recovery pathways (ERAS) whose fundamental tenets include minimal use of narcotics, nasogastric tubes, and drains; implementation of goal-directed fluid therapy; optimization of preoperative nutritional state; early postoperative mobilization; and early resumption of enteral nutrition. In patients who cannot comply with a strict ERAS pathway due to a chronic debilitated or malnourished state with anticipated prolonged return of bowel function, TPN is begun or reinstituted as soon as the patient is stabilized postoperatively.

## Wound Management

Surgical site infection is now a primary quality indicator for both hospitals and individual surgeons. It is also reported to national monitoring agencies in the United States. As such, efforts to minimize its occurrence are standardized and highly encouraged. SQIP guidelines recommend use of perioperative antibiotics;

aggressive skin decontamination prior to surgery; standardized skin prep with chlorhexidine alcohol; strict perioperative glucose control; maintenance of cooler operative temperatures; use of wound protectors; changing gown, gloves, and instruments prior to wound closure; maintenance of euglycemia and normothermia perioperatively; removal of sterile dressing within 48 hours; daily wound cleanse with chlorhexidine. These interventions have been shown to significantly decrease the rate of SSI. A reduction of SSI from 19% to 6% has been reported with implementation of these measures.

# Small Bowel Anastomosis

Complications specifically related to small bowel resection and anastomosis include anastomotic leak hemorrhage, stricture, internal herniation, folate, or vitamin $B_{12}$ deficiency, and short bowel syndrome. The chief concern regarding complications in the immediate postoperative period is the occurrence of an anastomotic leak. This is a potentially devastating problem that may lead to sepsis and death. The leak can cause intra-abdominal abscess, fistula formation, or both. Management of enteric fistulae was previously discussed. Certain factors increase the likelihood of an anastomotic leak including prior radiotherapy, carcinomatosis, severe malnutrition, peritonitis or intra-abdominal sepsis, and poor condition of the bowel. There are recent data suggesting that infection with collagenase-producing bacteria (*Enterococcus faecalis* and *Pseudomonas aeruginosa*) is implicated in anastomotic failure that is not directly attributable to technical factors.

Recurrent or persistent small bowel obstruction related to extensive dense adhesions is an uncommon occurrence that frustrates the patient and the surgeon and appears at the time to be an unsolvable dilemma. Although investigations continue, there is no proven available method for preventing redevelopment of the adhesions. Rather, described operative techniques for managing such patients have consisted of attempts to control the pattern in which the bowel adhesions form, such that there are smooth, gradual, nonobstructing turns in the small bowel. Currently, the main

approach to patients with primary or recurrent small bowel obstruction related to complex adhesions consists of complete adhesiolysis alone or together with internal bowel stenting.

The value of decompression with adhesiolysis is unclear, but it is the authors' practice to perform retrograde decompression concomitantly. In such cases, the authors place a gastrostomy tube for management if the obstruction fails to resolve. When adhesive small bowel obstruction persists postoperatively or develops after very extensive surgery, patients should remain on TPN and bowel rest for several weeks prior to considering reoperation, provided that the presentation is nonacute. Early reoperation on such patients may prove difficult and morbid due to an intense inflammatory reaction with edema and friability involving the bowel and peritoneal cavity, and there is high risk for development of postoperative fistula.

Significant postoperative hemorrhage from a bowel anastomosis is an uncommon occurrence. It usually occurs early and has been related to intestinal stapler malfunction. As previously discussed, this complication is best prevented by inspection of the staple lines following removal of the stapling instrument and is frequently self-limited or can be managed endoscopically.

After extensive small bowel resection, functional capacity of the intestine may be markedly reduced, resulting in several problems for the patient. The ability of the patient to adapt and maintain homeostasis with the remaining small intestine is dependent on several factors, including the length and specific segment of remaining bowel, the presence of an ileocecal valve and length of intact colon, the age of the patient (minimal intestinal adaptation occurs after age 65), and hormonal factors. Significant problems occur when fewer than 150 cm of functional small bowel remain, including severe diarrhea, dehydration, perianal or stoma excoriation, electrolyte imbalance, and malnutrition. Over several months, adaptation of the remaining intestine occurs, with variable improvement in diarrhea and malabsorption depending on the previously cited factors.

Intestinal hypersecretion occurs when ileostomy output exceeds 1.5-2 L in a 24-hour period. Interventions that can mitigate hypersecretion include treatment with scheduled opiates, use of H2

blockers, fiber, and antidiarrheal agents. Other complications that may develop in patients with short bowel syndrome include cholelithiasis and nephrolithiasis. At the time of surgery, if <3 ft (100 cm) of small bowel is preserved, especially in the absence of an intact ileocecal valve, consideration should be given to bringing the segment out as a stoma to improve patient comfort and dietary freedom.

In patients expected to be long-term survivors dependent on TPN, another consideration is prophylactic cholecystectomy. Following surgery, intestinal adaptation is dependent on stimulation by luminal nutrients. Patients receiving TPN should be supplemented with oral/enteral feeding. Depending on the length of remaining functional bowel, supplementation may vary from need for only additional vitamins to complete reliance on TPN.

# Colorectal Anastomosis

After colorectal anastomosis, patients can resume a regular diet on postoperative day 1. Routine nasogastric suction is not necessary but should be maintained in complicated cases. Patients at increased risk for an anastomotic leak from malnutrition, low anastomosis, diabetes, heavy tobacco use, severe vascular disease, prior irradiation, and severe blood loss/shock should be kept at complete bowel rest and on TPN for at least 10 days. Once the patient is taking solid food, a bulk-forming agent should be added to the diet. Another consideration is performing a diverting (“protective”) ostomy is considered.

Anastomotic leak is the most serious complication associated with colorectal anastomosis, and occurs in ~5% of patients with an associated mortality ranging from 10% to 30%. Depending on the level of the anastomosis and the length of time since surgery, the leakage may present as diffuse peritonitis and sepsis (if leak occurs within the first 48 hours), localized peritonitis, abscess, or a rectovaginal fistula. If there is clinical uncertainty about a leakage, a gentle contrast enema should be performed. Feculent or purulent drainage noted from a pelvic drain is another sign of possible leak. A pelvic drain positioned away from the anastomosis and placed at the

time of surgery is generally removed after 24-48 hours. If a clinically occult or localized small leakage is noted and the patient is otherwise well, the drain should be left in place and the patient placed on bowel rest and TPN to maximize chances of spontaneous healing. Most clinically evident anastomotic leaks require prompt laparotomy (emergent if the patient has peritonitis) and resection of the anastomosis, proximal colostomy, irrigation of the abdomen, and closure and/or wide drainage of the rectal stump.

Anastomotic stenosis occurs in 1%-10% of patients undergoing colorectal anastomosis. The likelihood of this complication occurring may be much higher in patients who have undergone pelvic radiotherapy for carcinoma of the cervix. In patients who have a protective colostomy, it is particularly important to evaluate the anastomosis for the presence of stenosis prior to reversing the colostomy. After healing, some anastomotic strictures can be successfully dilated.

Postoperative bleeding from the anastomosis is uncommon in the absence of a bleeding diathesis. The diagnosis may be difficult to make and should not be aggressively pursued unless the bleeding is significant. If the bleeding persists, hemostatic agents administered through an arterial catheter can be considered, although there is a risk of inducing ischemia at the site of the anastomosis. If the anastomosis was to the anus, an attempt should be made at suture ligation transanally. Endoscopic cauterization of staple line bleeding is possible, but hemorrhage resulting in hemodynamic instability and transfusion requirement rarely responds to endoscopic therapy. In the presence of significant bleeding not amenable to the above approaches, surgical exploration is necessary.

Like all extensive pelvic operations, surgery involving the colorectum carries the risk of ureteral injury that may be recognized during the postoperative period. Following a low rectal resection, a Foley catheter should be left in place for a minimum of 5 days. If there has been an associated extensive pelvic resection around the bladder for gynecologic malignancy or dissection around a previously radiated bladder, the catheter should be maintained for at least 3-4 weeks. As with extensive radical hysterectomy, bladder dysfunction is to be expected after extensive pelvic resection.

Following colorectal anastomosis, the patient may experience problems with rectal function including incontinence, tenesmus, and frequency of defecation. This constellation of symptoms is often referred to as low anterior resection syndrome and is more likely to occur with anastomoses to the distal rectum and particularly those performed below the anorectal angle. Medical management of such patients consists of dietary supplements (including a bulking agent), constipating agents (including narcotics), and behavioral modification or biofeedback. If a reasonable rectal stump length was maintained, these problems can be managed and should resolve within 6 months in most patients.

# Intestinal Stomas

Postoperative care begins in the operating room, where the surgeon must take responsibility for proper placement of the initial ostomy appliance so that contamination of the incisions and the psychological effects that early leakage can cause are avoided. The initial bag should be transparent so that the stoma can be checked for viability. Once the patient begins to recover from surgery, postoperative teaching about stoma management begins. Along with continued emotional support, this includes information about the anatomy of the stoma and its function, potential complications, and detailed aspects of day-to-day care. As with preoperative teaching, an enterostomal therapist is a valuable resource not only in the perioperative period but as long as the stoma is present extending to months postoperatively when patients are seen in clinic.

Specific concerns to be reviewed with the patient include peristomal skin care, diet, activities, odor, and emotional support. Some patients with an end-descending or sigmoid colostomy are candidates for routine irrigation that may allow predictability of bowel movements and better control over odor and gas. This is possible in patients with preserved colonic length and may even allow for freedom from a colostomy appliance and bag when routine irrigations are performed.

Complications of ileostomy and colostomy are similar, although succus entericus associated with small bowel surgery is more

caustic to the skin than fecal matter. Many gynecologic oncology patients undergoing ileostomy have advanced malignancy and will not experience late complications. One complication unique to ileostomy is food bolus impaction, which occurs close to the stoma. This situation may be difficult to differentiate from mechanical small bowel obstruction. In either case, the initial management consists of bowel rest with nasogastric suction and intravenous fluids. The ileostomy is then gently irrigated to dislodge the impaction. A windsock enema may be administered to allow gentle irrigation using gravity of an impacted small or large bowel stoma. Other common ostomy-related complications include peristomal wound infection, peristomal skin problems, site choice issues, ischemia, retraction, stenosis, prolapse, herniation, and carcinomatous involvement.

Peristomal skin problems include contact dermatitis, fungal dermatitis, and hyperplasia. Attention to appliance application and removal, avoidance of leakage, and meticulous skin care will decrease the incidence of these problems. An improperly placed stoma will make appliance placement and general stomal care more difficult for the patient and can contribute to the above skin problems.

Ischemia of the ostomy is more likely to occur with a descending colostomy and usually develops within days of stoma creation. The stoma must be closely monitored during the first 24 hours, and inspected for signs of necrosis. This may be done endoscopically or by simply placing a clear test tube into the stoma (**FIG. 38.30**) and shining a penlight inside the tube to assess the level of necrosis and stoma retraction. If the level of involvement is superficial and above the level of the fascia, then it is best managed by local wound care with later revision as necessary. Recession of the stoma and/or stenosis are potential consequences of ischemia. Frank stomal necrosis requires close monitoring and exploration if peritoneal signs develop. Significant retraction of the stoma is more common with a colostomy and occurs in ~3% of cases. With a retracted stoma, leakage under the stoma appliance is much more likely. Revision can usually be accomplished by freeing the stoma completely so that it can be elevated, secured to the fascia, and sutured to the skin in a Brooke fashion (bowel is everted and sutured to skin exposing the mucosal surface as an elevated stoma). Significant stomal stenosis

may be a consequence of ischemia or infection or may result from a too narrow skin or fascial opening. This complication occurs in ~3% of colostomy patients. Initial gentle dilation may resolve the problem, but persistent stenosis requires revision. Revision with excision of the constricting scar tissue is the best approach.

**FIGURE 38.30** Examination of the lumen of a necrotic stoma with a test tube.

Stomal prolapse develops as a consequence of excess fascial opening and more commonly involves the proximal limb of a

transverse loop colostomy. This complication occurs in 3% of colostomy patients. Local revision with resection of the redundant colon, closure of the fascial defect, and fixation to the fascia are the surgical principles for repair. If the colostomy is temporary, prolapse may be managed expectantly until it is time for reversal of the stoma.

A peristomal hernia develops in ~4% of patients after colostomy and is also a result of too large fascial opening. The hernia is repaired by excision of the sac and closure of the fascial defect with mesh. Relocation may be necessary when large hernias are present, or patients experience recurrent hernias (**FIG. 38.31**).

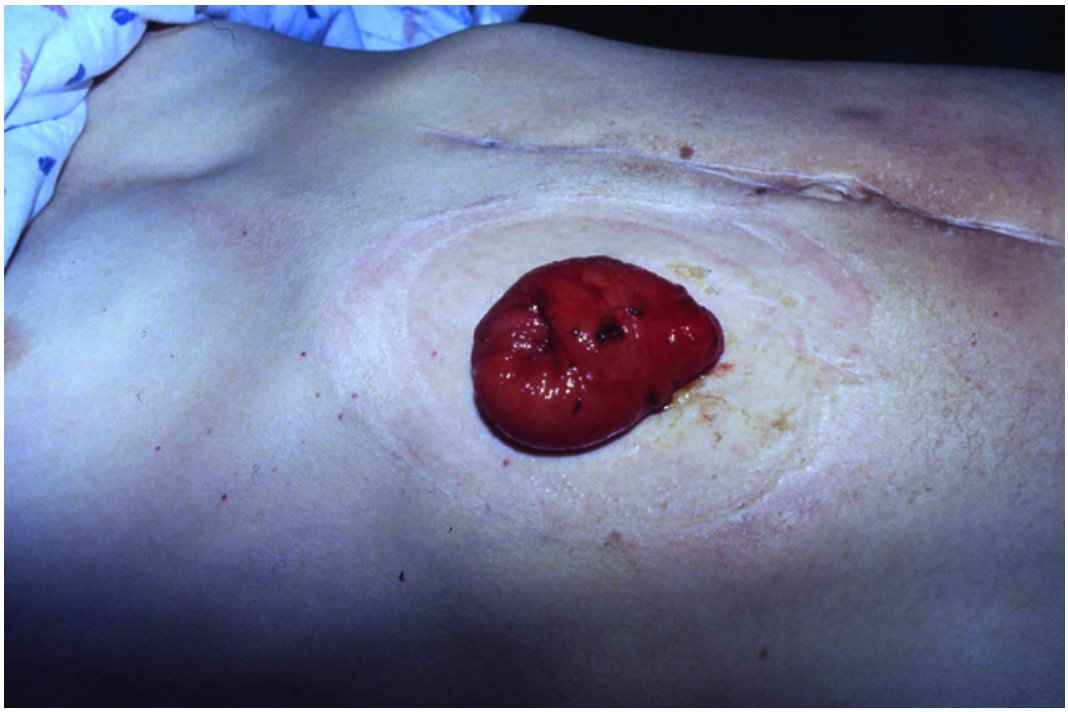


**FIGURE 38.31** Prolapsed loop colostomy.

Carcinomatous replacement of the stoma occasionally occurs in patients with advanced intra-abdominal malignancy. Resection and relocation of the stoma is ideal but often not feasible. Local radiotherapy may also be considered. These patients face difficulty with odor, pain, and control of ostomy effluence and tumor discharge.

# Ostomy Closure

Many complications that occur after colostomy closure in gynecologic cancer patients are related to the extensively radiated and/or extensively resected colorectum. Complications specifically related to closure of a loop ileostomy or colostomy are similar to those of other bowel anastomoses. These include wound infection (12%), anastomotic leak or fecal fistula (6%), anastomotic stricture or obstruction (2%), and incisional hernia (6%).

Factors contributing to development of complications include patient age, timing of operation, underlying pathologic abnormality, type and site of colostomy, steroid dependence, moderate to severe malnutrition, use of oral preoperative antibiotics, method of closure, and experience of the surgeon. Timing of closure is controversial but should be delayed until the condition of the patient is optimal, especially when there has been an inflammatory process of the colon or peritoneal cavity or when the colon has been radiated. Closure of an end colostomy has been simplified using a stapling device; the closure-related complication rate is probably not significantly greater than that of a transverse loop colostomy.

## KEY POINTS

- Management of thermal bowel injury is highly individualized according to the perceived extent of damage. Blanched, contracted tissue should be considered nonviable. There may be at least several millimeters of damage beyond the apparent injury.
- Laceration of the small bowel should be repaired perpendicular to the lumen to avoid constriction.
- For a patient with recurrent ovarian cancer and bowel obstruction, the presence of extensive ascites, bulky intra-abdominal tumor, no radiographic transition zone, or generally poor condition indicates that surgical management of the obstruction is unlikely to be of benefit.

- The surgical approach to a patient with radiation-related small bowel obstruction must be individualized. If the overall condition of the patient is poor or there is recurrent disease, the fastest and least complicated procedure (ie, simple bypass or ileostomy) should be undertaken. If there is impending necrosis of the involved bowel, if multiple injuries to the bowel have occurred during dissection, or if the involved bowel is a simple loop that is not densely adherent, resection with end-to-end enterocolostomy is preferred. Isolation bypass may still be applicable in some of these cases. Matted loops of bowel in the irradiated pelvis should be left in place if a reasonable length of proximal small bowel can be bypassed and anastomosed to nonirradiated proximal colon.
- Initial management of the patient with a small bowel fistula includes of bowel rest with nasogastric suction, fluid and electrolyte resuscitation, skin care, control of sepsis, and nutritional support.
- During conservative management of small bowel obstruction, if the patient develops signs of compromised bowel, surgery must proceed. If, however, the patient remains stable and the bowel decompresses well, there is no urgency to the situation. The patient can be maintained on TPN, allowing 5-10 days for the condition of the bowel to improve and for the obstruction to resolve. If the bowel does not decompress by 48-72 hours, surgery should be planned.
- The operative approach to bowel resection begins with careful planning of resection and anastomosis followed by mobilization of the involved portion or portions of the bowel. The bowel to be anastomosed must be healthy, have an adequate blood supply, and reapproximate without tension.
- Following anastomosis of the small bowel, the chief complication of concern in the immediate postoperative period is an anastomotic leak. This is a potentially devastating and may lead to sepsis and death.
- After extensive small bowel resection, functional capacity of the intestine may be markedly reduced, resulting in several

problems for the patient. Significant problems occur when <5-10 ft of functional small bowel remain, and include severe diarrhea, dehydration, perianal or stoma excoriation, electrolyte imbalance, and malnutrition.

- Anastomotic leak is the most serious complication of colorectal anastomosis, with a reported incidence of ~5% and an associated mortality ranging from 10% to 30%.

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# CHAPTER 39

# MANAGEMENT OF SURGICAL HEMORRHAGE

Emma Rossi

**Surgical Preparation**
**Surgical Management of Hemorrhage**
Management of Venous Bleeding
Management of Arterial Bleeding
Vascular Ligation Procedures
Large Vessel Repair
Packing for Control of Hemorrhage
**Adjuncts to Control of Hemorrhage**
Use of Clips
Electrosurgery
Hemostatic Agents
Vascular Clamp Placement
**Blood Replacement**
Autologous Blood Transfusion
Blood Product Replacement
Nonsurgical Interventions for Hemorrhage
Use of Antifibrinolytic and Other Agents
**Management of Hemorrhage in Minimally Invasive Surgery**

**Postoperative Management**

**Conclusion**

Surgical hemorrhage is defined as intraoperative blood loss exceeding 500cc or blood loss requiring transfusion. It occurs in ~2% of gynecologic procedures. Prompt, careful interventions can prevent catastrophic sequelae when hemorrhage occurs. Patient and clinical factors that increase a patient's risk for intraoperative hemorrhage should be identified preoperatively and modified when possible. Gynecologic procedures that are associated with higher risk for bleeding include hysterectomy or myomectomy for enlarged fibroid uteri, the presence of malignancy, endometriosis due to obliteration of avascular planes, and lymphadenectomy because of the proximity of lymph nodes to the major vessels.

# SURGICAL PREPARATION

Once risk factors have been identified, modifications or preparations can be made to mitigate the risk or extent of hemorrhage. Patients taking anticoagulant medications should discontinue these as appropriate, or transition to short-acting reversible agents as a "bridge." Decision-making that is coordinated with the prescribing provider is ideal to safely preoperatively manage these agents and minimize the risk of intraoperative bleeding. For example, it may be safe to avoid "bridging" with short-acting anticoagulants for some patients with atrial fibrillation. Conversely, patients on anticoagulation for prophylaxis of mechanical heart valves, drug eluting coronary stents, or recent venous thrombolic events may require continuation of anticoagulant or antiplatelet therapy up until the time of surgery. Coordination should be made with relevant specialist medical providers to guide the timing for restarting these agents postoperatively (**e-TABLE 39.1**).

# e-TABLE 39.1
# Anticoagulation Reversal Agents and Treatment Strategies

| ANTICOAGULANT | TIMING OF DISCONTINUATION | REVERSAL AGENTS |
|---|---|---|
| Warfarin | 5 d | **Reversal:**<br>INR 2-5 (no bleeding):<br>Lower warfarin dose or omit a dose and resume warfarin at a lower dose when INR is in therapeutic range<br>INR 5-9 (no bleeding):<br>Omit the next 1-2 doses, monitor INR, and resume when INR is therapeutic; or omit a dose and administer 1-2.5 mg oral vitamin K<br>INR > 9 (no bleeding):<br>Hold warfarin. Administer 2.5-5 mg oral vitamin K. Monitor INR; administer more vitamin K if needed. Resume warfarin at a lower dose when INR is therapeutic<br>**If surgery within 24 h:**<br>INR < 4.5 (no bleeding): vitamin K 2.5 mg IVPB<br>INR ≥ 4.5 (no bleeding): vitamin K 5 mg IVPB<br>**If emergency surgery:**<br>INR < 4.5 (no bleeding): vitamin K 10 mg IVPB<br>INR ≥ 4.5 (no bleeding): vitamin K 10 mg IVPB<br>**Any INR + emergent reversal for life-threatening hemorrhage in adults:**<br>4-FPCC (preferred approach)<br>3-FPCC (if 4-FPCC is not available)<br>FFP + 10 mg vitamin K by slow IV infusion (if 4-FPCC or 3-FPCC is not available) |
| Heparin | | Protamine sulfate |
| Direct thrombin inhibitors<br>Dabigatran (Pradaxa) | CrCl ≥ 50 mL/min: 1-2 d<br>CrCl < 50 mL/min: 3-5 d | **Minor bleeding:** Local hemostatic measures, possible anticoagulant discontinuation, consider antifibrinolytic agents (tranexamic acid, epsilon-aminocaproic acid)<br>**Major bleeding:** Drug discontinuation, hemodialysis, oral activated charcoal, tranexamic acid, epsilon-aminocaproic acid<br>**For life-threatening bleeding:**<br>Idarucizumab (Praxbind) 5 g—FDA approved (first line)<br>Factor VIII inhibitor bypassing activity (FEIBA) 50-100 units/kg, followed by PCC 25-50 units/kg as second-line option<br>Avoid: recombinant activated factor VII, FFP or cryoprecipitate |
| Factor Xa inhibitors<br>Rivaroxaban (Xarelto)<br>Apixaban (Eliquis)<br>Edoxaban (Lixiana, Savaysa)<br>Betrixaban (Bevyxxa) | ≥24 h<br>ROCKET AF trial: ≥3 d | **Minor bleeding:** Local hemostatic measures, possible anticoagulant discontinuation, consider antifibrinolytic agents (tranexamic acid, epsilon-aminocaproic acid)<br>**Major bleeding:** Drug discontinuation, oral activated charcoal, tranexamic acid, epsilon-aminocaproic acid. Hemodialysis not effective because direct factor Xa inhibitors are highly protein bound<br>**For life-threatening bleeding:**<br>4 factor PCC (Kcentra, Octaplex) 25-50 units/kg<br>Avoid: recombinant activated factor VII, FFP or cryoprecipitate |
| Antiplatelet agents<br>Aspirin<br>Clopidogrel | High CV risk/minor: continue<br>Low CV risk/high-bleed risk: 7-10 d<br>5 d | |

Onset of action for oral vitamin K: 6-12 h, peak effect 24-48 h. Onset of action for IV vitamin K: 1-2 h, peak effect 1-2 h, peak effect 12-14 h. The direct oral anticoagulant reversal agents for life-threatening bleeding have the potential to cause life-threatening thrombosis and should only be used under the direct supervision of a specialist with expertise in their use and/or in a patient at imminent risk of death from hemorrhage. High-quality evidence from randomized trials is lacking in these strategies, and recommendations are based on data from case series.

CrCl, creatinine clearance; CV, cardiovascular; 3 PCC, prothrombin complex concentrates (contains factors II, IX, and X; little to no factor VII); 4 PCC, prothrombin complex concentrates (contains factors II, VII, IX, and X).

Patients who are at risk for having significant bleeding due to patient or procedural factors should be prepared for blood loss. This will arm the surgeon with better responsiveness in the operating room. Preoperative labs should include a measure of hemoglobin and hematocrit; a patient with preoperative anemia is more likely to manifest significant hemodynamic symptoms from a large blood loss compared with a patient who enters surgery with normal lab values (**TABLE 39.1**). Pretransfusion testing, such as a "type and screen" for ascertainment of the ABO blood group and antibody screen, should be ordered on most patients undergoing major gynecologic procedures. However, patients at higher risk for hemorrhage should be considered for a cross-matching of blood products, which identifies and holds units of blood ready for transfusion. This expedites the process in which these blood products can be made available in the operating room during periods of rapid or significant blood loss. Anticipating transfusion will facilitate prompt and adequate volume resuscitation and avoid sequelae of acidosis and coagulopathy. Blood products are an expensive and limited resource. Therefore, cross-matching blood products should be reserved for high-risk patients and procedures (**TABLE 39.2**).

## TABLE 39.1
## Tests to Assess Coagulation Status

| TEST | REFERENCE RANGE[a] | ABNORMAL VALUE | SIGNIFICANCE |
|---|---|---|---|
| Hematocrit (%) | 37-47 | 25 | Tissue anoxia |
| White cell count (mL) | $4 \times 10^3$ to $12 \times 10^3$ | $3 \times 10^3$ to $25 \times 10^3$ | Susceptibility to infection, leukemia |
| Platelet count (mL) | $140 \times 10^3$ to $400 \times 10^3$ | $100 \times 10^3$ to $700 \times 10^3$ | Bleeding, myeloproliferative disorder |
| Fibrinogen (mg/dL) | 150-400 | 100 | Bleeding, liver disease, intravascular consumption |
| Prothrombin time (s) | 10-13 | 14 | Bleeding factor deficiency |
| Activated partial thromboplastin time (s) | 28-38 | 40 | Bleeding factor deficiency, inhibitor |
| PFA-100 | Collagen-epinephrine | Prolonged closure time | Screen for medication effect |

[a]Reference ranges may vary in each laboratory, reflecting method, instrumentation, and reagents.

## TABLE 39.2
## Risk Factors for Coagulation Disorders

| |
|---|
| History of spontaneous bruising or bleeding |
| History of unusual bruising or excessive bleeding after surgery |
| Family history of bruising or bleeding after surgery |
| Taking medication associated with bruising or bleeding |
| Current medication associated with bleeding alteration within past week |
| Previous coagulation testing |
| Current coagulation testing |

Procedural preparation is also important and begins with communication with key operating room stakeholders such as the operating room nursing and anesthesiology teams. If the nursing team is made aware of the potential for hemorrhage, appropriate equipment such as suture material, heme clips, retractor sets, and hemostatic agents can be ordered. Anticipatory communication with the anesthesiology team can make them aware of the need for multiple wide caliber peripheral sites or high-flow central catheters. Hemodynamic monitoring, cardiac support drugs, and resuscitative fluids can be requested when there is a risk of hemorrhage. This preparation results in earlier initiation of resuscitative efforts and can save valuable minutes that can be lifesaving and prevent organ damage from hypoperfusion.

# SURGICAL MANAGEMENT OF HEMORRHAGE

When faced with hemorrhage, it is important to avoid surgical interventions which unintentionally increase bleeding or cause injury to adjacent structures. Surgeons should focus on smooth deliberate movements rather than rushed maneuvers and application of inappropriate force. Excessive use of monopolar electrosurgery can

cause unintentional thermal injury to adjacent structures. Blindly placed sutures within pools of blood can result in accidental ligation of critical structures, such as the ureter. Failure to acknowledge the volume of blood loss or ongoing losses will delay resuscitation.

## Management of Venous Bleeding

Venous bleeding that is difficult to isolate can steadily accumulate and frustrate the surgeon. Application of pressure to tamponade the vein is the first step to control bleeding. What may appear to be significant bleeding from a venous source may occasionally be made hemostatic with simple sustained pressure because the inherent lower venous pressure promotes stasis and clot formation in the setting of tamponade.

If simple sustained extrinsic compression is unsuccessful, surgeons should then consider closing the venous defect with clips or sutures. Placing sutures is a good approach when venous bleeding occurs in awkward locations, such as the deep pelvic sidewalls, the parametria, or paracolpos. Sutures are also a preferred method to obtain hemostasis in close proximity to vital structures, such as the ureter, bladder, or bowel wall. Figure-of-8 or interrupted sutures are the most useful method to achieve hemostasis as they can reapproximate vascular edges with minimal anatomic distortion. A careful touch is required when placing these stitches. Care should be made to pass the needle deeply and far back enough from the edge to prevent tearing through tissue. However, suture placed too deeply can inadvertently pass through or narrow unintended structures. This is particularly concerning in locations such as the cardinal ligament where poorly placed sutures can narrow or completely obstruct the ureter.

## Management of Arterial Bleeding

The brisk bleeding that ensues from an arterial source can rapidly fill the surgical field. Access to suction to clear the field and isolate the vessel is important. In cases of significant hemorrhage, a second suction unit may be necessary to restore and maintain visualization.

Arterial bleeding is typically pulsatile, which can make the identification of the source more apparent. If arterial bleeding arises from a severed or inadequately secured vessel that can be sacrificed such as the uterine artery, inferior mesenteric artery, or anterior branch of the internal iliac artery, the vessel can be clamped and sutured or clipped in a manner that closes its lumen. However, when the source of arterial bleeding is from an artery that should not be sacrificed such as the aorta, the external iliac artery, or the posterior branch of the internal iliac artery, closure of the defect with suture should be planned to avoid compromising luminal patency or closing the vessel itself (**VIDEO 39.1**). If these critical vessels are the source of hemorrhage and control of the defect is not possible without compromising its integrity, consultation with vascular surgery specialists should be requested as reconstruction or bypass procedures may be necessary.

## Vascular Ligation Procedures

Arterial ligation results in decreasing vascular pulse pressure, thus controlling downstream bleeding. This approach is a therapeutic option when there is broad surface bleeding from multiple sources of a shared supply. Basic principles of arterial ligation include exposure of the vessel through retroperitoneal space development, skeletonization of the artery free from its investing connective tissue, and effective sealing of the artery while protecting adjacent critical structures.

Ovarian artery ligation can control bleeding from an ovary or as a strategy to diminish bleeding from the uterus by decreasing sources of perfusion. If the ovary remains attached to the uterus at the utero-ovarian ligament, it will receive enough collateral flow to remain viable after ovarian artery ligation. To perform this ligation, the retroperitoneal space should be entered by making an incision in the peritoneum lateral to and parallel with the ovarian vascular pedicle. This peritoneal incision should be extended above the pelvic brim to facilitate identification of the ureter in the retroperitoneal space, deep to the ovarian vessels. Once the ovarian vascular pedicle is

skeletonized, the ovarian artery can be identified within the bundle, isolated, and clipped or suture ligated (**FIG. 39.1**).

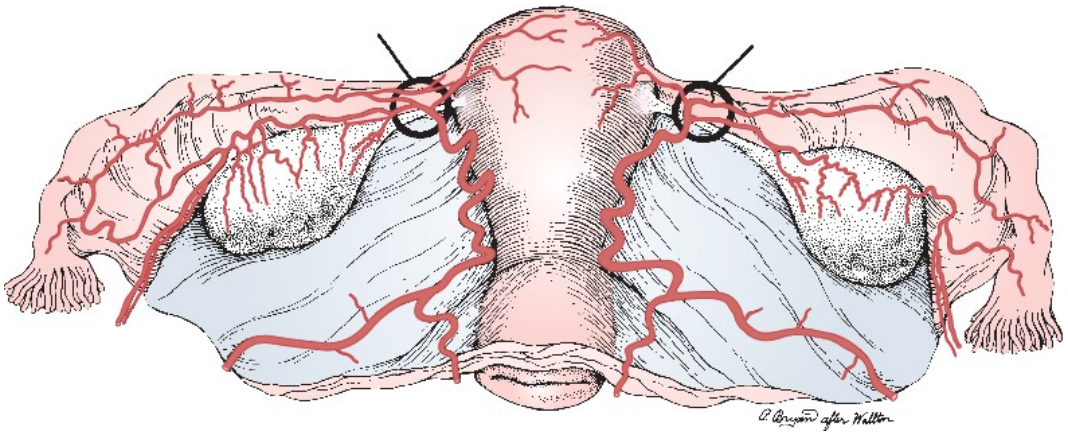


**FIGURE 39.1** In addition to ligation of the anterior division of the hypogastric arteries, the blood flow to the uterus through the ovarian arteries can be ligated in the medial mesosalpinx without interfering with the blood flow to the tube and ovary.

Uterine artery ligation (UAL) is another strategy to control hemorrhage from the uterus such as that occurring during myomectomy or hysterectomy. To perform UAL, the retroperitoneal space must be deeply opened to create the avascular space known as the pararectal space. This potential space is created when the ureter is mobilized off of its lateral attachments to the internal iliac artery. This exposes the anterior branch of the internal iliac artery, which gives rise to the uterine artery as one of its first branches. It is imperative that the ureter within the broad ligament is comprehensively mobilized medially off of this vascular structure. The uterine artery may appear somewhat tortuous. The uterine vein is located deep to the uterine artery and, therefore, care should be made to ensure that the uterine artery is closely skeletonized without unintentionally causing bleeding from the deeper vein. Once isolated

and skeletonized close to its origin, it can be ligated with a surgical clip or suture ligature. Electrosurgical devices should be used with great caution when sealing the uterine artery at this location due to its close proximity to the ureter.

Internal iliac artery ligation, also commonly called hypogastric artery ligation, decreases the perfusion pressure of the entire hemipelvis and decreases bleeding from broad sources in the pelvis (**FIG. 39.2**). The retroperitoneal space should be opened as previously described and the peritoneal incision opened above the level of the pelvic brim. The ureter is identified at the bifurcation and is mobilized medially, away from the arteries. Once the iliac bifurcation is identified, the proximal internal artery should be skeletonized from its invested lymphatic and fatty tissue. A retractor, such as a malleable retractor, remains in the pararectal space, medial to the internal iliac artery, serving to protect the ureter. A fine-tipped clamp such as a right-angled clamp should then be carefully passed from lateral to medial underneath the internal iliac artery taking care to hug the artery so as not to injure the vein; the internal iliac vein resides immediately deep and lateral to the artery and, therefore, the clamp should closely approximate the artery as it travels behind the structure. It is important to pass the clamp from lateral to medial in order to prevent damage to the external iliac vein, which might occur if the tip of a clamp is passed in the opposite direction toward the fixed and fragile venous structure. The clamp should be placed distal to the posterior division of the internal iliac artery, so that only the anterior division is ligated. The posterior division most commonly arises from within 2 cm of the bifurcation; therefore, ligation at 1-2 in (3-5 cm) from the bifurcation of the external and internal iliac artery spares this branch. Ligation of the posterior division of the internal iliac artery can result in buttock claudication and ischemia. Accidental ligation of the external iliac artery will results in distal limb ischemia; checking pedal pulses after ligation can reassure the surgeon that the external artery was not ligated. Once the clamp has been passed and its tips exposed, suture material can be fed into the open tips, clamp extracted and suture is tied, thus ligating the artery. The suture chosen is typically a delayed absorbable braided suture such as polyglactin. It is

appropriate to select the most appropriate diameter suture to successfully occlude this structure, and this decision is based on the caliber of the vessel. Suture ligation is usually successful, and there is no need for division of the artery (**BOX 39.1 TABLE 39.3**).

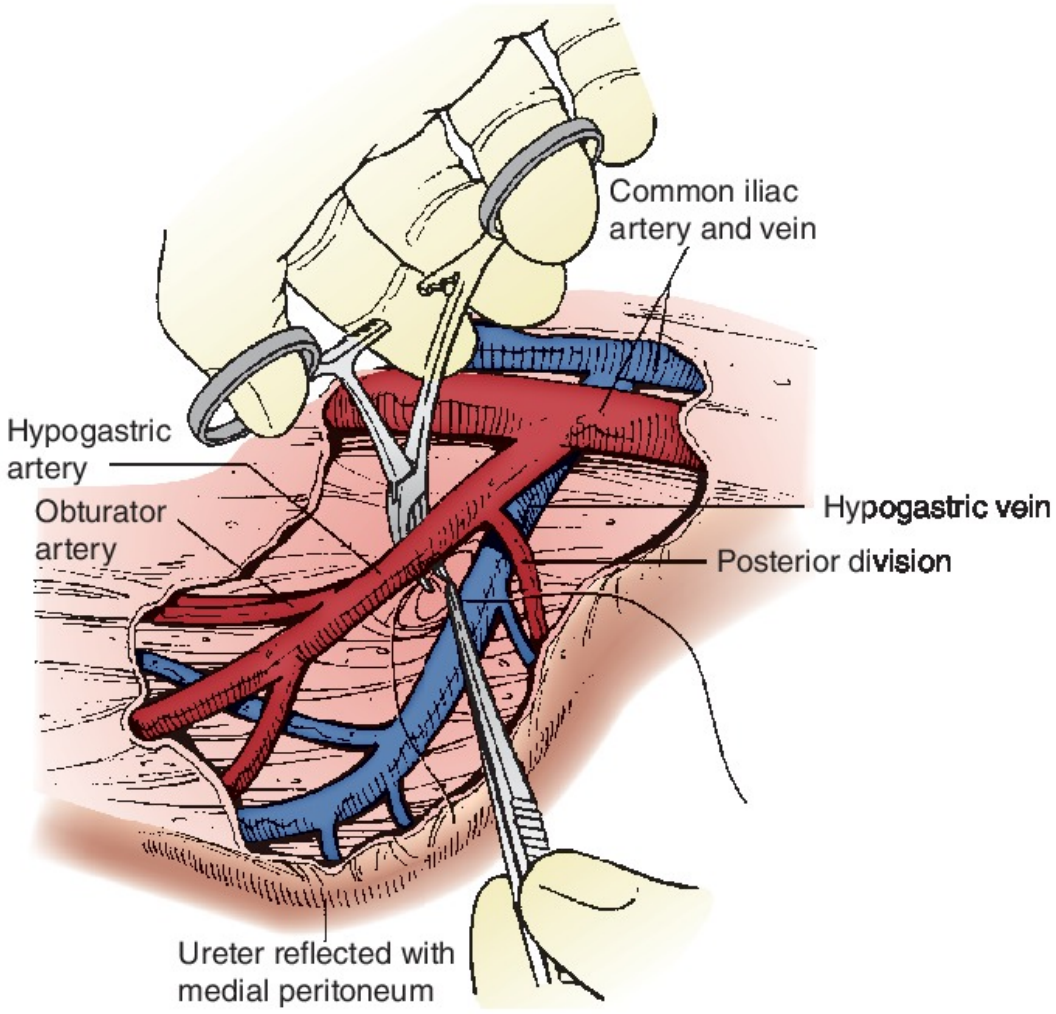



**FIGURE 39.2** Ligation of the right hypogastric artery. The clamp is passed from lateral to medial, and the ligature is placed around the anterior division of the hypogastric artery. Note the ureter is attached to the peritoneum, which is reflected medially.

# BOX 39.1 STEPS IN THE PROCEDURE

## Surgical Control of Pelvic Hemorrhage

## Hypogastric Artery Ligation

- Open the peritoneum over the external iliac artery from the round ligament to the infundibulopelvic ligament.
- Identify the hypogastric artery at its origin from the common iliac artery or at the medial margin of the psoas muscle, and follow it up to the common iliac artery bifurcation.
- Leave the ureter attached to the medial peritoneal reflection.
- Identify the hypogastric vein more laterally on the pelvic sidewall.
- If possible, identify the anterior and posterior branches of the hypogastric artery.
- Pass the clamp lateral to media, 2 cm distal to the origin of the hypogastric artery, and feed nonabsorbalble suture into tips. Tie suture.
- Place a second free-tie suture distal to the initial ligature to avoid recanalization. Tie down the suture.
- Do not divide vessel.

## Ovarian Vessel Ligation

- Extend the lateral peritoneal incision cephalad and parallel to the infundibulopelvic ligaments.
- Identify the ureter.
- Ligate the ovarian vessel with a single, permanent ligature, avoiding the ovarian vein.
- A single clip also can be placed on each ovarian artery as a quicker and easier method of occlusion.

## Uterine Artery Ligation

- The uterus should be elevated upward and angled away from the targeted uterine artery.
- Identify the uterine artery by visualization or palpation.
- A 0 absorbable suture is passed into and through the myometrium 2 cm medial to and below the uterine vessels. The needle is brought out through an avascular area in the broad ligament, cephalad and lateral to the uterine vessels. The suture is securely tied.

### TABLE 39.3
### Possible Complications of Internal Artery Ligation[a]

| |
|---|
| Injury to internal iliac artery |
| Ligation or injury to ureter |
| Ligation or injury to external iliac artery |
| Injury to internal and external iliac vein |

[a]Also called hypogastric artery ligation.

# Large Vessel Repair

Most cases of large vessel injury, such as injury to the aorta, vena cava, or iliac vessels, will require the assistance of a specialist vascular or trauma surgeon to repair. However, in some cases, gynecologic surgeons may need to attempt a repair in order to stabilize the patient, particularly if the injury is small and does not require grafting or bypass. Thus, understanding the basic concepts of a safe vascular repair is important.

The vessel wall of large arteries, such as the aorta and iliac arteries, have multiple well-defined layers including the basement membrane, tunica intima, tunica media, and tunica externa. Basic

principles for closing an arterial defect include making an intima to intima closure, inclusion of all three layers of the vessel to prevent development of arterial dissection, and prevention of luminal narrowing from over aggressive closure or by not closing the defect perpendicular to the direction of blood flow. A narrow caliber, nonabsorbable monofilament suture such as 5-0 polypropylene is ideal for this purpose. Either interrupted sutures or a continuous running closure should be employed. Surgeons should refrain from placing figure-of-8 suture configurations, which can narrow and distort the lumen or tear through the vessel wall, thus exacerbating the injury. It is normal to encounter bleeding from suture puncture sites. One should avoid placing additional sutures to control this but rather apply compression and/or topical hemostatic agents for control of suture-site bleeding.

A similar technique is employed to suture a vascular defect in a major vein, such as the vena cava; however, due to the thinner wall of the vein, it can easily be traumatized during repair. Similar to the principles employed for arterial closure, care should be taken to avoid narrowing the lumen, and to include full thickness perpendicularly placed sutures.

## Packing for Control of Hemorrhage

When efforts to control hemorrhage with surgical intervention are not successful, it may be prudent to delay definitive repair and extricate the patient from the operating room, focus on volume and blood product resuscitation, correction of coagulopathy, and plan to re-evaluate and repair as an interval procedure.

Placement of temporary packing in the surgical field applies extrinsic compression to minimize active blood loss. It can be extremely effective in temporizing and possibly resolving uncontrollable hemorrhage. To create a pack, multiple sponges or bandage rolls are placed within a sterile bag. Options for sterile containment bags include inert, nonpermeable barrier bags such as Bogota bags (a sterilized 3-liter irrigation bag), Steri-Drape, or Silastic cloths. Enough sponges within containment bags should be placed over the bleeding area to apply adequate tamponade. If the

vaginal cuff is open, and the source of bleeding is the pelvic floor, a parachute arrangement can be created in which the strings of the bags, with sponges contained within, are brought through the vaginal cuff and weighted down to create downward compression on the pelvic floor (**FIG. 39.3**).

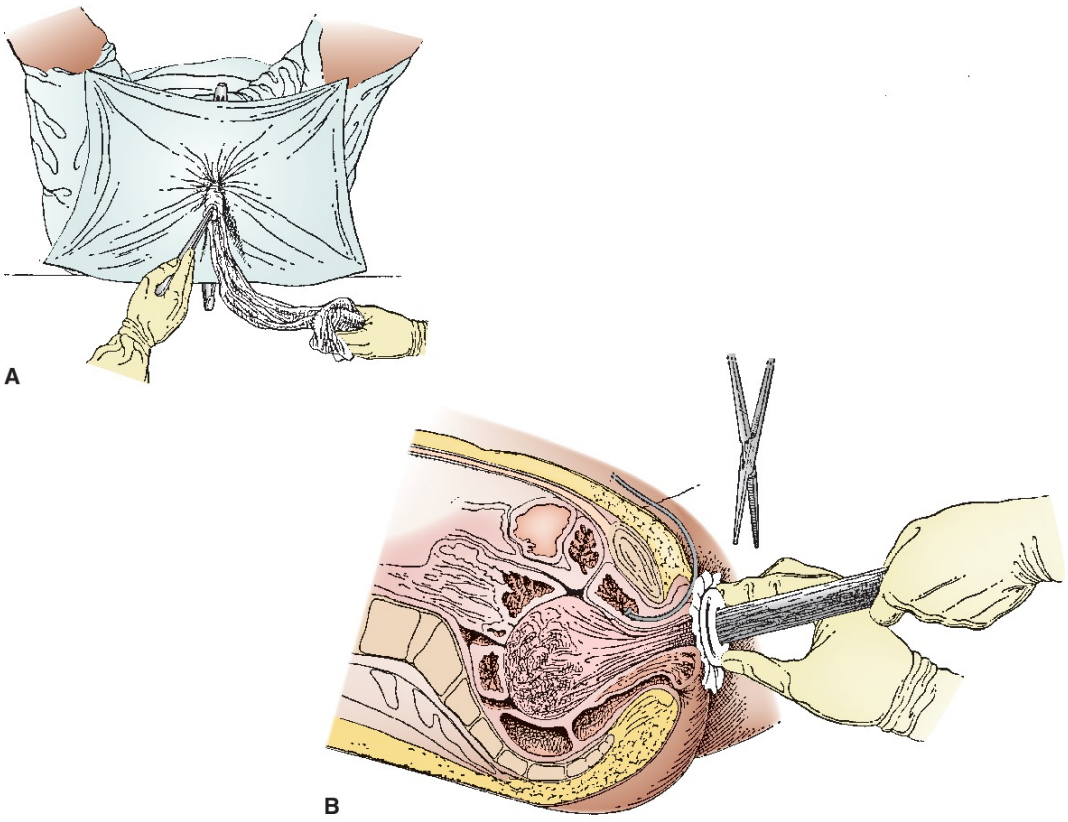



**FIGURE 39.3** The parachute pack can be used to control bleeding from the deep pelvic veins. **A.** A plastic sheet or towel is packed with gauze rolls through the vaginal or perineal opening. **B.** The ball of gauze packing is then pulled down to exert pressure against the vessels of the pelvic floor.

Once the bleeding site has been packed, the abdomen should be loosely closed. The fascia should remain open to avoid the development of abdominal compartment syndrome. Drains can be placed within the peritoneal cavity to measure ongoing bleeding, and the skin should be simply closed with widely spaced intermittent stables and an occlusive dressing in anticipation of need to return to the operating room for pack removal and abdominal closure.

The ABThERA system (KCI, San Antonio, TX, USA) Open Abdomen Negative Pressure Therapy is a system that is designed for managing open abdomens when packs are placed. This system provides temporary protection of the wound and underlying viscera while providing negative pressure to remove fluid. A foam sponge pad is placed across the surface of bowel and viscera, followed by application of an occlusive, adherent dressing. A negative pressure device is then attached to the dressing and the suction created from the device effectively draws the wound edges together. This device, or similar configurations, is easily removed for planned or emergent re-evaluation of the surgical field (**FIG. 39.4**).

**FIGURE 39.4** An open abdomen negative pressure system can serve as a temporary abdominal closure when primary closure is not possible and/or repeat abdominal entries are anticipated. Its purpose is to remove peritoneal fluid, reduce edema, protect abdominal contents, and provide rapid access for reentry. (Reprinted with permission from Mulholland MW. *Greenfield's Surgery*. 6th ed. Wolters Kluwer; 2016. Figure 25.3.)

After hemorrhage is temporized by packing, patients are taken to the intensive care unit intubated, sedated, and paralyzed. This allows for volume resuscitation, correction of anemia and coagulopathy, and surgical planning for definitive repair or intervention. Return to the operating room typically takes place 48 hours later provided no intervening emergency has developed. If the initial procedure was unable to be completed (eg, bowel anastomosis), then this is an opportunity to complete the planned procedure.

Once the patient is taken back to the operating room, the closure system is carefully removed and the packing is gently and systematically removed. Careful attention should be made to account for all foreign bodies, such as sponges, that were placed at the initial surgery. It is common that with time, compression, and correction of coagulopathy, active hemorrhage is controlled and minimal additional work is needed to resolve bleeding.

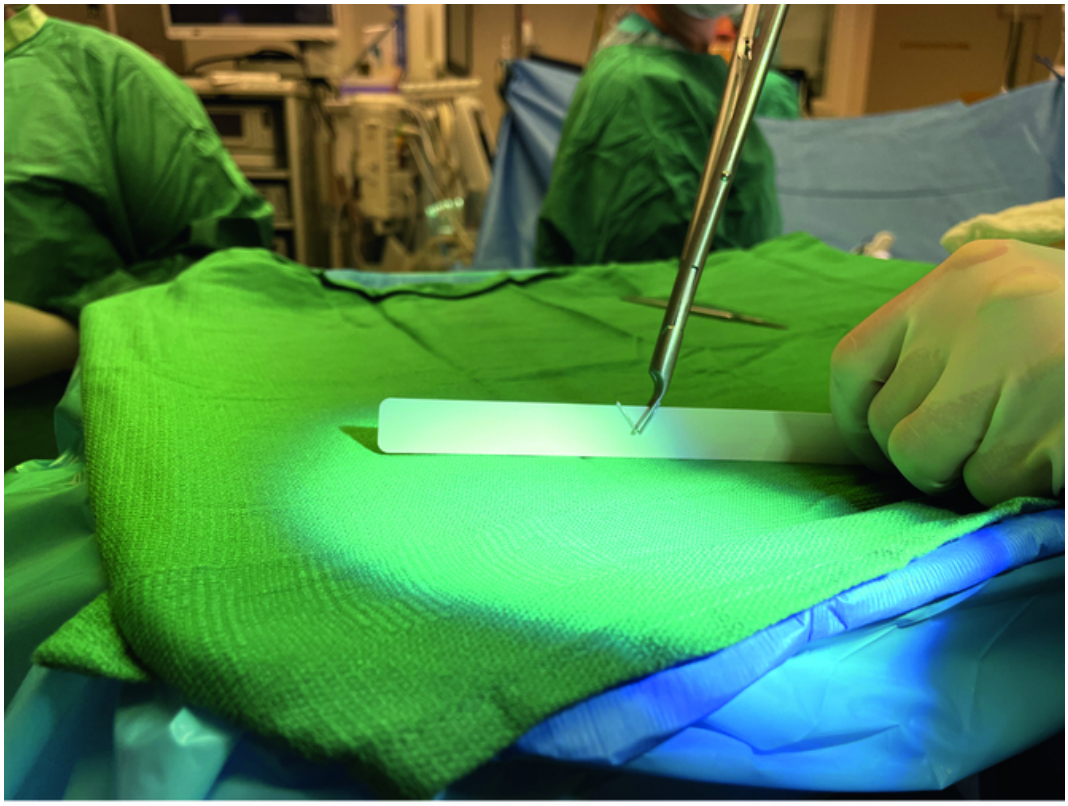
# ADJUNCTS TO CONTROL OF HEMORRHAGE

## Use of Clips

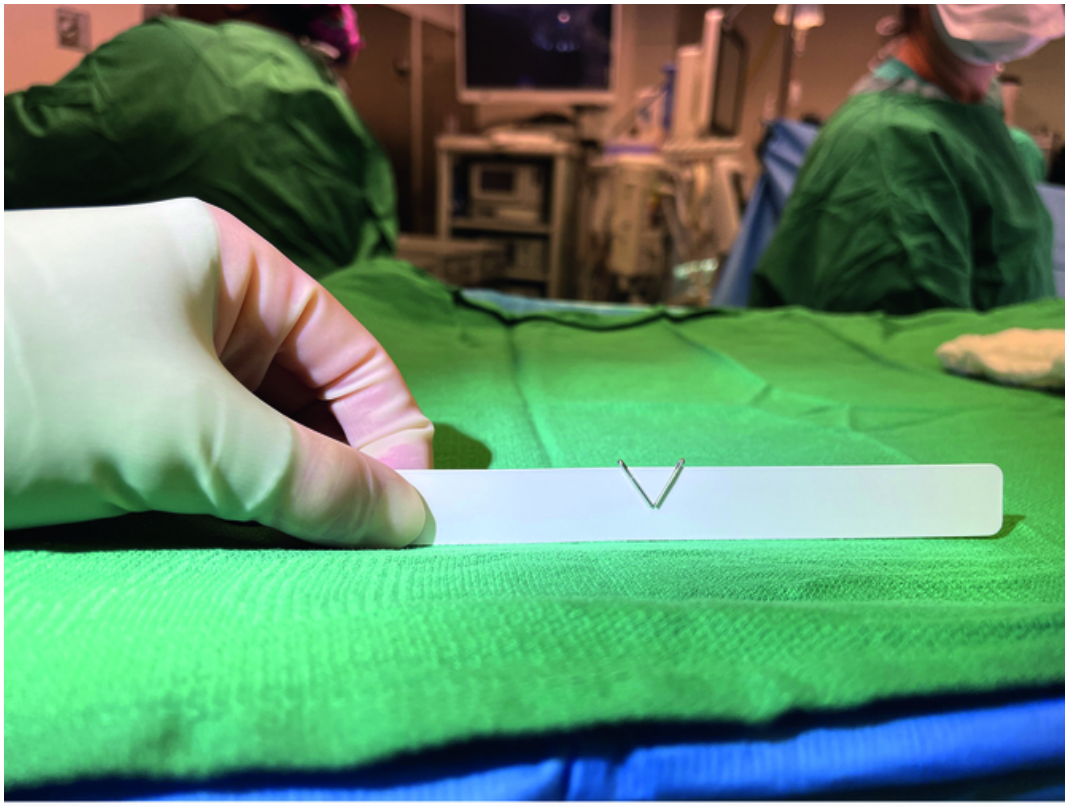
Placement of surgical clips should be considered when there is brisk bleeding from well-circumscribed areas. Several forms of surgical clips exist including metal or polymer variations and are available for both the laparoscopic and open approaches. Clips are available in varying sizes from 2 to 28 mm. Surgeons should select the size of clip that is most suitable to close the defect. Clips that are too large for the defect can either unintentionally include adjacent structures or slip or catch on instruments and sponges. Alternatively, if inadequately small clips are chosen, they will fail to close the defect necessitating additional measures. Once an inadequately sized or inappropriately placed clip is positioned, it can be difficult to remove without further damaging the underlying tissues and can interfere with the placement of other clips or closure techniques.

The ideal placement of surgical clips includes placement of two abutting clips oriented in a “V.” This orientation is best able to close the defect while preventing narrowing of the underlying vascular lumen. Clips, like suture, allow for the surgeon to avoid the use of electrosurgery in close proximity to vital structures. However, due to their bulky, rigid applicators, clips can be difficult to place in narrow spaces or where visualization is limited. Additionally, clips are fixed in size, and therefore may not afford the surgeon the same flexibility as suture placement to conform to the shape and location of the source of bleeding (**FIG. 39.5A-C**).

A



B



C

**FIGURE 39.5** **A.** Clip appliers and clip cartridge. **B and C.** Clips should be applied in "V" formation.

## Electrosurgery

Use of electrosurgical equipment can be very effective for tissue dissection and to control bleeding; however, extreme care should be taken with these devices due their potential for causing unintended injury to adjacent structures. In cases of hemorrhage, there is typically little use for the discharge of monopolar diathermy current. This form of energy typically creates hemostasis through development of an eschar. However, current spreads beyond the eschar to cause "thermal" injury to susceptible structures such as the bowel wall or urologic structures. In cases of hemorrhage where visualization may be limited, simple monopolar diathermy is often unsuccessful, resulting in ongoing bleeding, poor visualization, and a tendency to continue with discharge of futile monopolar current. The buildup of surgical eschar serves as a conductor of current, which then more effectively passes this current to adjacent structures, rather than resolving the underlying bleeding. A more effective use of monopolar diathermy is to discharge the current onto a pair of carefully placed vascular forceps gripping a discrete piece of tissue between their blades. This creates a bipolar effect (**FIG. 39.6**).

**FIGURE 39.6** Apply monopolar diathermy to a vascular forceps gripping a discrete piece of tissue to create a bipolar effect.

Bipolar energy sources of electrosurgical current are more valuable in the setting of hemorrhage control. Bipolar clamping devices (such as Ligasure, Covidien) serve as active clamps, closing and sealing the vessels or structure simultaneously. They typically have minimal lateral spread of current and can be more safely used in closer proximity with sensitive structures.

## Hemostatic Agents

Topical hemostatic agents constitute a broad group of agents, which include physical agents and biologic agents. The former create a physical matrix promoting thrombus formation, whereas the latter augment the coagulation cascade at the site of injury. Topical

hemostatic agents are most useful when deployed in cases of low volume, low pressure bleeding, or in cases where there are diffuse bleeding surfaces. These agents are of variable cost, with the biologic agents typically costing more than the physical agents. **TABLE 39.4** lists commonly available hemostatic agents and their mechanism of action.

## TABLE 39.4
## Tissue Sealants and Hemostatic Agents

| | AGENT | COMPONENTS |
|---|---|---|
| **Physical (Mechanical) Agents** | | |
| | Bone wax | Beeswax, paraffin, isopropyl palmate |
| **Dry Matrix (Topical Absorbable)** | | |
| | INSTAT | Bovine microfibrillar collagen power |
| | Avitene, Helistat, Ultrafoam | Microfibrillar collagen |
| | SURGICEL, SURGICEL FIBRILLAR, SURGICEL NU-KNIT | Oxidized regenerated cellulose |
| | SURGICEL SNoW<br>Arista, Vitasure | Polysaccharide spheres |
| | Surgifoam, Gelfoam | Porcine gelatin |
| **Biologically Active Agents** | | |
| | Thrombin-JMI | Bovine thrombin |
| | EVITHROM | Pooled human thrombin |
| | Recothrom | Recombinant thrombin |
| Flowable | FLOSEAL | Bovine gelatin matrix and pooled human thrombin |
| | SURGIFLO | Bovine gelatin (and/or thrombin) |
| Fibrin sealants | TISSEEL | Pooled human plasma (human fibrinogen, thrombin, aprotinin) |
| | Crosseal | Human fibrinogen, thrombin, tranexamic acid |
| | EVARREST Fibrin Sealant Patch | Human fibrinogen and human thrombin embedded in a flexible composite patch |
| | Vitagel | Patient's own plasma and bovine thrombin |
| | CryoSeal | Patient's own plasma |
| | EVICEL | Fibrinogen and thrombin |
| Synthetic sealants | CoSeal | Synthetic polyethylene glycol |
| | BioGlue | Bovine serum albumin, glutaraldehyde |

Examples of agents that act through physical or structural mechanisms include oxidative regenerating cellulose, microfibrillar collagen, polysaccharide spheres, and porcine gelatin. These agents create scaffolds upon which platelets become activated and organize as a clot. To effectively achieve hemostasis, a patient needs an

adequate volume of functional platelets. These agents are available as sheets or sponges and can be intentionally placed at sites of bleeding. Use of topical sheets creates a functional blanket over the source of bleeding, and these are particularly useful when treating flat wide areas of bleeding.

Agents with biologic mechanisms include thrombin, thrombin with gelatin, and fibrin, and these agents act to create a fibrin clot. These agents are typically dispensed in liquid form but can also be used with the application of a sponge to enhance adherence to the site of bleeding. An example of this would be applying thrombin to a gelatin sponge. Sponges and liquid agents are preferable for use in deeper spaces.

Hemostatic agents are valuable for controlling persistent, difficult to control bleeding. However, they have been associated with abscess formation, small bowel obstruction, and thrombus. This is particularly true of the physical/mechanical group of hemostatic agents that are most significantly associated with risk of infection or abscess, likely due to their delayed absorption and potential to form a physical nidus of infection. These are costly agents; therefore, gynecologic surgeons should reserve use of topical hemostatic agents for management of persistent bleeding rather than as a routine, prophylactic measure.

# Vascular Clamp Placement

When hemorrhage occurs from a large caliber major vessel, such as the vena cava, aorta, or iliac arteries, the defect may require a complex repair. In order to accomplish this, the vessel must be compressed to prevent ongoing losses. If clamps that are not specialized for vascular occlusion are applied, there can be resultant trauma to the vessel that compounds the injury. Clamps specific to vascular repair should be chosen such as Bulldog clamps and Satinsky clamps.

Bulldog clamps are lever-activated devices that can be placed on a vessel on the afferent and efferent aspects from the injury. They are atraumatic clamps and effectively pinch to occlude the vessel, minimizing blood loss from the defect while its repair is initiated.

Alternatively, Satinsky clamps can temporarily cross clamp large vessels or longitudinally close defects while preparing for definitive closure (**FIG. 39.7**).

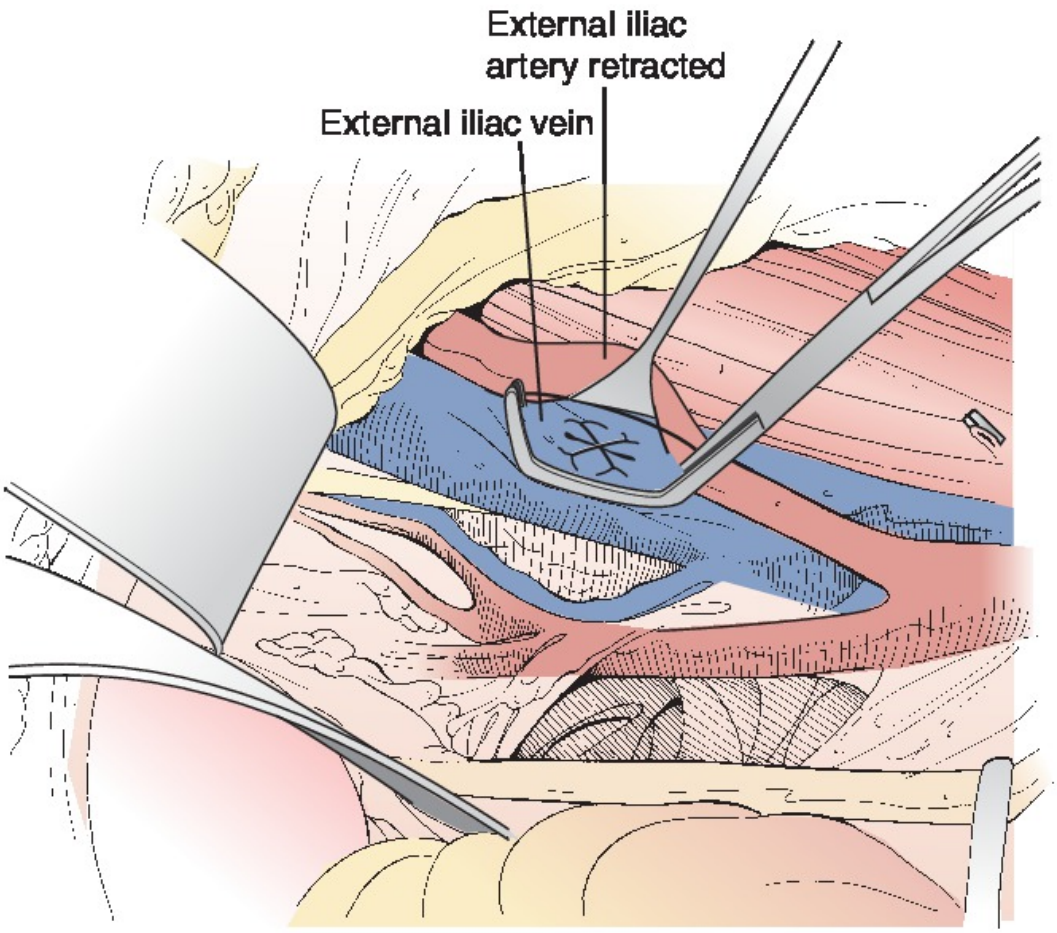



**FIGURE 39.7** Placement of clamp on vein laceration in preparation for repair. (Reprinted with permission from Cundiff GW, Azziz R, Bristow RE. *Te Linde's Atlas of Gynecologic Surgery*. 1st ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2013.)

Vascular clamps are not typically available on gynecologic surgical trays; therefore, they are unlikely to be the first choice for vascular lumen compression. A laparotomy sponge applied directly to the injury site with manual compression is both immediate and effective. However, this strategy results in handicapping the surgeon and limits their visualization of the injury and preparation for repair. An alternative strategy to tamponade is the use of two sponge sticks applying direct pressure to the vessel upstream and downstream from the injury. The long handles of the sponge sticks move the surgeons' hands out of the surgical field and allow for exposure and planning. The atraumatic nature of the sponges within the jaws of the ring forceps prevents trauma to the vessel walls and adjacent structures (**FIG. 39.8**).

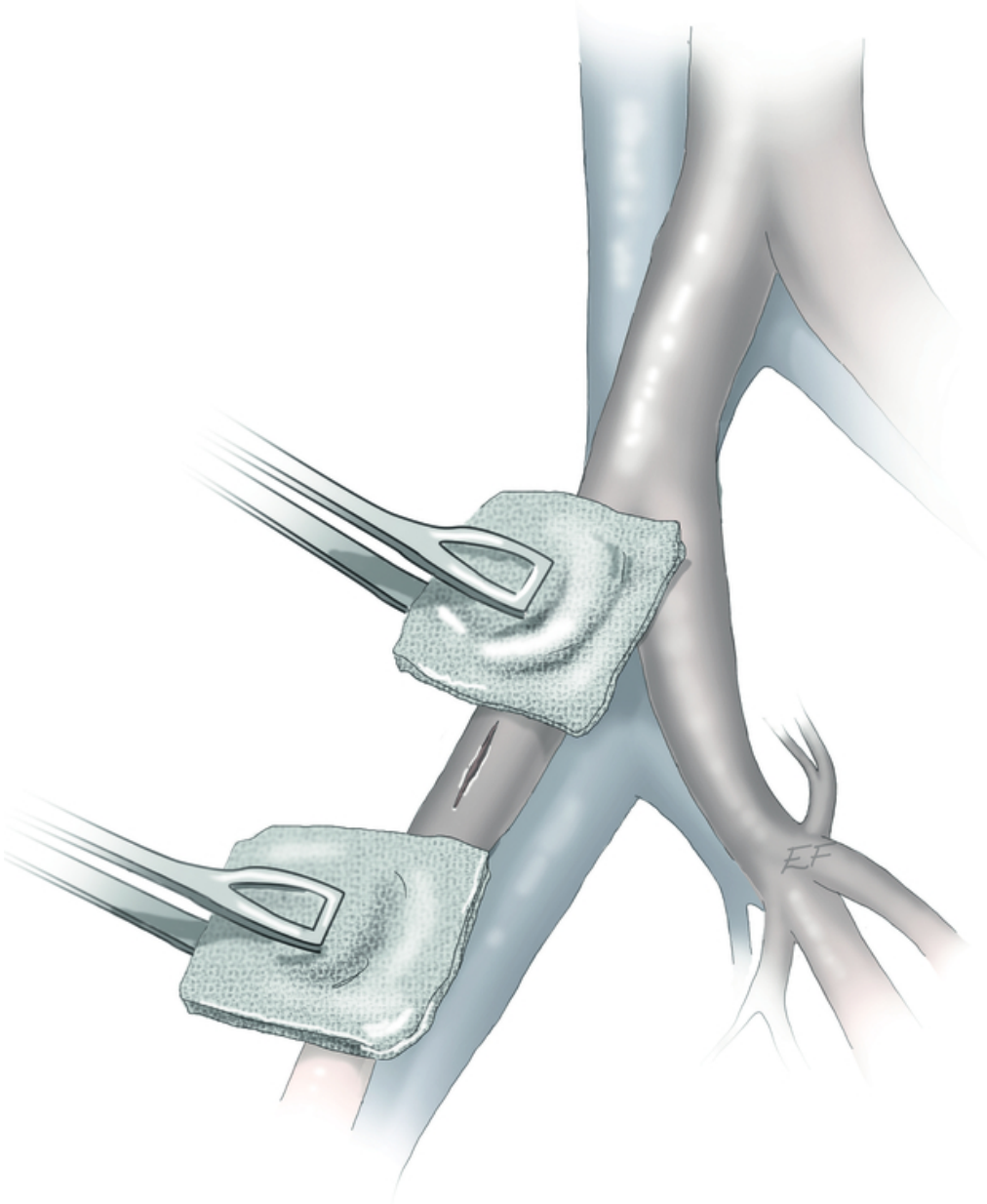


**FIGURE 39.8** Sponge sticks are applied proximal and distal to vascular injury to decrease blood flow and allow visualization of defect for repair. Used with permission of McGraw Hill LLC from Walker JL. Ancillary procedures. In: Karlan BY, Bristow RE, Li AJ, eds. *Gynecologic Oncology: Clinical Practice*

*and Surgical Atlas.* McGraw-Hill Medical; 2012:679. Figure 33-7; permission conveyed through Copyright Clearance Center, Inc.

When applying compression or clamps directly to major vessels, the surgeon should be mindful of the integrity and health of the vessel. For example, patients with extensive peripheral vascular disease may have significant atheromatous plaque buildup, and compression or clamping of these vessels can cause displacement and embolization of plaque resulting in distal ischemia. Surgeons should also be mindful of the downstream vascular tributaries, which are interrupted by temporary cross clamping. If major vessels are occluded, the operating room staff should be asked to document the time, and 5-minute intervals should be called out to make all aware of the potential for development of ischemia in distal structures. Venous return can be impaired when the vena cava that is cross clamped or compressed, and in the setting of hemorrhage, this may further exacerbate acidosis and hypoperfusion. Clear communication with the operating room team is critical to ensure that patient well-being is not compromised in response to management of a vascular defect (**BOX 39.2**).

## BOX 39.2 STEPS FOR MANAGEMENT OF HEMORRHAGE

### Surgical Control of Pelvic Hemorrhage

- Initial Assessment and Management.
- Apply pressure with a finger using a laparotomy sponge.
- Suction adjacent areas to improve visibility.
- Expose pedicle by gently rolling off the bleeding pedicle. If able, grasp bleeding pedicle with DeBakey forceps or a right-angle clamp.

- Depending on the size of pedicle and proximity to adjacent structures, may apply a surgical clip, electrocautery if a small bleeder, or suture ligate.

### Persistent or Excessive Bleeding

- Apply continued pressure (take precaution to not dislodge any previously placed surgical clips). Assess whether bleeding is amenable to hemostatic agents and apply if indicated.
- Notify anesthesia and OR nursing staff of brisk bleeding. Check stability of patient and keep warm. Estimate blood loss, ensure IV access is adequate, send labs, and notify blood bank of need for blood products. Activate mass transfusion protocol if needed.
- Request for additional help:
- Additional Yankauer suction or specific instruments
- More scrub or circulating OR nurses
- Intraoperative consults (eg, gynecologic oncologist, urologist, colorectal surgeon, general surgeon, vascular surgeon)

## BLOOD REPLACEMENT

When intraoperative blood loss exceeds 15% of the patient's estimated blood volume, the surgeon should consider red blood cell transfusion to replace the acute blood loss. As a general rule, 15% of an adult's blood volume (in milliliters) equals the patient's weight (in kilograms) times 10. For example, for a 75-kg woman (165 lb), 15% of blood volume is (75 × 10) 750 mL. When considering the risks and benefits of transfusing blood, the patient's estimated blood volume and hemoglobin/hematocrit prior to surgery, the estimated intraoperative blood loss, the anticipated additional blood loss, and the risk of hypoxic and metabolic complications should be considered (**TABLE 39.5**).

# TABLE 39.5
# Blood Transfusion Reaction or Infection Risks

| DISEASE OR SITUATION | RISK |
|---|---|
| **Viral Infection** | |
| Hepatitis B | 1:989,841 |
| West Nile Virus | 1:350,000 |
| Hepatitis C | 1:1,980,534 |
| HIV | 1:1,606,972 |
| HTLV | 1:4.4 million |
| **Transfusion Reactions, Immediate** | |
| Allergic (mild, urticarial reaction) | 1:20 |
| Fever/chills (nonhemolytic) | 1:50 |
| TACO | 1:100 |
| TRALI | 1:12,000 |
| Acute hemolytic (mistransfusion) | 1:40,000 |
| Acute hemolytic (incompatible plasma) | 1:50,000 |
| Delayed hemolytic reaction | 1:50,000 |
| Septic reaction (apheresis platelets) | 1:100,000 |
| Anaphylactic reaction | 1:500,000 |

HIV, human immunodeficiency virus; HTLV, human T-cell lymphotropic virus; TACO, transfusion-associated circulatory overload; TRALI, transfusion-related acute lung injury.

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# Autologous Blood Transfusion

Cell savers collect, wash, and resupply patients with an autologous (individual origin) transfusion. This approach is particularly advantageous for patients in whom allogenic (donor origin) blood transfusion is not desired or matched blood is difficult to obtain such as when the patient possesses red blood cell antibodies. Use of cell savers and autologous transfusions can minimize the quantity of allogenic blood products used when used as an adjunct in surgery. Traditionally, due to potential cost and utilization of skilled personnel, the use of cell saver devices has been restricted to cases in which they are most likely to benefit the patient. Typical indications for cell saver use include anticipated blood loss >20% of the patient's blood volume, procedures for which blood is typically cross-matched, procedures for which the rate of allogenic transfusion is >10%, and there is anticipation that transfusion of more than one unit of packed red cells will be required. Other criteria for receipt of autologous blood are listed in **TABLE 39.6**.

## TABLE 39.6
## Criteria for Elective Preoperative Autologous Blood Donation

- A hemoglobin of ≥11 g/dL or Hct >34%
- Phlebotomy no more frequently than every 3 d and not within 72 h of surgery
- <80 y of age (relative indication)
- No active infection
- No angina
- No myocardial infarction in last 3 mo
- No congestive heart failure
- No aortic stenosis
- No hypertension

The key to effective use of a cell saver is anticipation of its potential need. Ideally “standby” setups are created for the procedure, which include suction tubing, a cardiotomy reservoir that includes a separation chamber, filtration system and storage reservoir, and an anticoagulant. The management of these devices is typically performed by a perfusionist specialist and ensuring they are available for the procedure is a component of appropriate case preparation.

Blood that is suctioned from the surgical field is captured within the cell saver reservoir where it is mixed with anticoagulant. It is then transferred to the cell washing and separation chamber, followed by extraction of red cells and eventual auto transfusion. Mixing of hypotonic or toxic solutions with the aspirate is a relative contraindication to use of a cell saver device. This might include sterile water, hydrogen peroxide, or alcohol. Cell saver use is relatively contraindicated for surgery in grossly infected or contaminated surgical fields and in cases of malignancy (particularly advanced stage malignancy).

While the use of a cell saver can be extremely valuable in replacing blood volume and avoiding excessive allogenic transfusion, it is limited by the need for anticipation and setup in addition to the potential costs involved. Therefore, when hemorrhage is anticipated and use of a cell saver is not contraindicated,

consideration should be ordering cell saver setup for the operative case.

## Blood Product Replacement

Initial resuscitation of hemorrhage typically involves the intravenous infusion of crystalloid solutions as a first step because they are immediately available to the anesthesia team in the operating room. Crystalloids should be infused in a 3:1 ratio to compensate for the low oncotic pressure of these agents relative to the blood that has been lost, which accounts for their brevity in restoring tissue perfusion pressures.

The decision to initiate transfusion during episodes of trauma should incorporate knowledge of the patient's underlying medical condition, their baseline hemoglobin and hematocrit, the volume of accumulated blood loss, and the anticipated total blood loss by factoring the source and potential for control of the active hemorrhage. Packed red blood cells and other blood factors are the best volume replacement with respect to preservation of hemodynamics and organ perfusion because these most closely resemble and restore what has been lost. However, in addition to the immediate risks of transfusion such as transfusion reaction and small risk of infection, it is understood that blood transfusion can be associated with worse perioperative outcomes independent of the underlying cause for transfusion. Blood products are a costly and limited resource; therefore, judicious decision-making is required with respect to authorizing transfusion (**TABLE 39.7**).

### TABLE 39.7
### Blood Products

| BLOOD PRODUCT | VOLUME (mL) | ADDITIONAL FACTORS | EXPECTED RESPONSE | COMMON INDICATIONS |
|---|---|---|---|---|
| PRBC<br>1 unit | 200-250 | Fibrinogen: 10-75 mg | Increase:<br>1 mg/dL Hgb<br>3% Hct | ABLA<br>MTP<br>Surgical blood loss |
| Platelets<br>SDP<br>RDP[a] | 300-500<br>50 per unit | Fibrinogen: 2-4 mg/mL (360-900 mg)<br>Clotting factors: Equivalent of 200-250 mL of plasma<br>"6 pack" of pooled RDP similar to SDP | Increase:<br>30-60 K/mm$^3$ | Plt count <10 K<br>MTP<br>Bleeding with known qualitative plt defect |
| FFP[b]<br>1 unit | 180-300 | Fibrinogen: 400 mg<br>Clotting factors: 1 mL contains 1 active unit of each factor | Decrease:<br>PT/INR<br>PTT | Coagulopathy<br>Warfarin overdose<br>DIC |
| Cryo<br>10 pack | | Fibrinogen: 1200-1500<br>Clotting factors: VIII, vWF, XII | Decrease:<br>PT/INR<br>PTT<br>Increase: Fibrinogen | vWD<br>DIC<br>Hemophilia A |

[a]4-10 RDP units are pooled prior to transfusion.

[b]Duration of FFP effect is ~6 hours.

ABLA, acute blood loss anemia; Cryo, cryoprecipitate; DIC, disseminated intravascular coagulation; FFP, fresh frozen plasma; Hct, hematocrit; Hgb, hemoglobin; MTP, massive transfusion protocol; plt, platelets; PRBC, packed red blood cells; RDP, random donor platelets; SDP, single-donor platelets; vWD, von Willebrand disease; vWF, von Willebrand factor.

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In the general population, blood transfusion is reserved for patients who have lost a blood volume that results in a hemoglobin of 7 g/dL. More liberal use of transfusion of packed red cells transfusion for hemoglobin <9 g/dL has been shown to be associated with increased mortality and perioperative complications; therefore, a more restrictive policy is recommended. Point of care testing can provide rapid feedback regarding the patient's hemoglobin levels. Unfortunately, this real-time feedback may be delayed due to a lack of vascular access or delays in laboratory testing. In cases of delayed laboratory feedback, surgeons and anesthesiologists should use estimated blood loss in conjunction with real-time patient hemodynamic factors such as heart rate, blood pressure, and urine output to estimate the need for intraoperative blood transfusion.

The patient's underlying medical comorbidities are also important considerations when determining the need to transfuse intraoperatively. Patients with underlying cardiovascular disease and cardiac valvular disease may be particularly sensitive to anemia,

decreased oxygen delivery, and pulse pressure and may require a more liberal approach to transfusion. Patients with preexisting anemia may have developed compensatory physiologic adjustments, allowing for tolerance of lower red cell content. However, less blood loss is necessary for a patient with preoperative anemia to reach critically low haemoglobin; therefore, transfusion may be necessary sooner for these patients who begin surgery with less reserve.

In cases of significant blood loss, there is a need to replace more than red cells. Transfusion with packed red cells should take precedent due its ability to provide oxygen carrying capacity to blood, particularly as preceding infusions of crystalloids or colloids may have caused hemodilution and decreased oxygen capacity even if volume is restored with these agents. However, if only crystalloids and packed red blood cells are transfused, the patient will deplete their coagulation factors and platelets. The consequence of relative dilution of these blood components is to exacerbate hemorrhage.

There are two approaches to restoration of blood components with transfusion. One approach prescribes a ratio of blood product transfusion, typically 2:1:1 for packed red cells: platelets: fibrinogen. The second approach is one in which component transfusion is guided by laboratory values of platelets and fibrinogen rather than by standard ratios. In studies comparing these two approaches during episodes of hemorrhage, there have been no difference in survival benefits observed with either approach.

Most institutions have massive transfusion protocols (MTPs). These MTPs should be initiated in cases where transfusion of more than 4 units of packed red cells is initiated or anticipated. They allow for rapid preparation and delivery of blood product components and facilitation of point of care testing to assist in decision-making regarding resuscitation. These protocols specify the institution’s preferred transfusion approach and are either ratio-based or clinically-guided component replacement algorithms. In cases of hemorrhage, the operating room personnel should contact the hospital’s blood bank to initiate this protocol. In addition to making blood products and testing more readily available, activation of the MTP should expedite delivery of equipment that speeds and

optimizes transfusion, such as pressure pumps to increase the speed of transfusion and warming devices to ensure that the large volumes of blood products transfused do not result in hypothermia which can exacerbate coagulopathy (**TABLE 39.8**).

## TABLE 39.8
## Example of Massive Transfusion Protocol (MTP)

**Criteria for Activation of MTP**

- Class IV shock and estimated requirements of at least 10 units of blood
- Both substantial acute or imminent blood loss and a likelihood that substantial blood loss will continue over short term and estimated requirements of at least 10 units of blood

*Initial Product Release*

- If MTP is activated, an immediate type and screen should be sent to the blood bank. Cycle 1 will be completed by blood bank personnel within 30 min of activation for transport to patient care unit
- Cycle 1 includes the following:
  - 10 units packed red blood cells
  - 6 units fresh frozen plasma
  - 1 unit platelets

*Continuation of MTP*

- The blood bank, by default, will continue to prepare cycles at least every 30 min until the protocol is discontinued
- Cycle 2 and all subsequent cycles include
  - 6 units packed red blood cells
  - 6 units fresh frozen plasma
  - 1 unit platelets

*Cessation of MTP*

- Decision to stop the MTP may be made by the attending or attending anesthesiologist
- Patient indicators for cessation of MTP include
  - Expiration
  - Hemodynamic stability
  - Attending or attending anesthesiologist's discretion

If laboratory-based transfusion rather than standard-ratio transfusion is employed as part of a massive transfusion protocol, fresh frozen plasma should be transfused when PT or aPTT values of >1.5 times normal. Platelet transfusions should be considered for serum platelets <50-100 000/μL, and cryoprecipitate is transfused when fibrinogen concentration values are <200 mg/dL. When the fibrinogen level falls below 100 mg/dL, transfusion of 20 units of cryoprecipitate will replenish fibrinogen; twenty units of cryoprecipitate will achieve therapeutic levels of fibrinogen quickly and permit monitoring over several hours. The intraoperative goal is to maintain PT <14 seconds, APTT <40 seconds, fibrinogen more than 100 mg/dL, and platelets more than 80 × $10^3$/mL.

# Nonsurgical Interventions for Hemorrhage

## *Embolization*

Percutaneous arterial embolization is a treatment option when there is evidence of ongoing bleeding from the surgical field not amenable to surgical repair particularly when there is bleeding from multiple downstream sites of a common vascular supply that are in aggregate difficult to control. This is commonly observed in obstetric hemorrhage particularly in cases of abnormal placentation, where embolization plays an important role in management of placentation bleeding. Embolization can be similarly employed for control of bleeding during gynecologic procedures and is considered for the patient who continues to bleed, has been packed, and the abdomen is temporarily closed. When the decision to embolize is made intraoperatively, the interventional staff should be called from the operating room. It is important that the patient is medically stabilized and optimized to tolerate an extended period of decreased access to the surgical field before transferring them directly to the interventional radiology suite. Embolization utilizes micro-coils, micro beads, or particles to occlude vessels and microchannels, thereby decreasing pulse pressure and resolving bleeding.

Intravascular embolization requires the expertise of a skilled interventional radiologist. Percutaneous catheterization of the femoral artery under local anesthesia provides direct access in a retrograde manner to the hypogastric artery (**FIG. 39.9**). The brachial artery can also be used for access to the vascular system. If prior hypogastric artery ligation has obstructed this pathway, arteriography of the pelvic vasculature through one of the collateral arteries usually localizes the specific bleeding vessel or vessels, although with greater difficulty. The site of bleeding can be accurately identified with angiography and fluoroscopy if the rate of bleeding is 2-3 mL/min or more. The hypogastric artery or the specific collateral vessel is cannulated for injection. A variety of materials can be used for embolization, including small pieces of Gelfoam (Pfizer), metal coils, small Silastic spheres, autologous clot, subcutaneous tissue, and other hemostatic materials. Gelfoam is one of the most practical and easily injected materials. It is sterile and nonantigenic, remains in the vessel for 20-50 days, and forms a fibrin mesh framework upon which blood clots can develop. Its immediate effect is to obstruct the distal artery or arteriole and reduce pulse pressure in the bleeding vessel, thereby permitting clot formation and cessation of bleeding. Material is injected under angiographic observation. When it becomes evident by repeat angiography that the bleeding vessel has been occluded, the catheter is removed and the patient is carefully monitored for evidence of further bleeding.

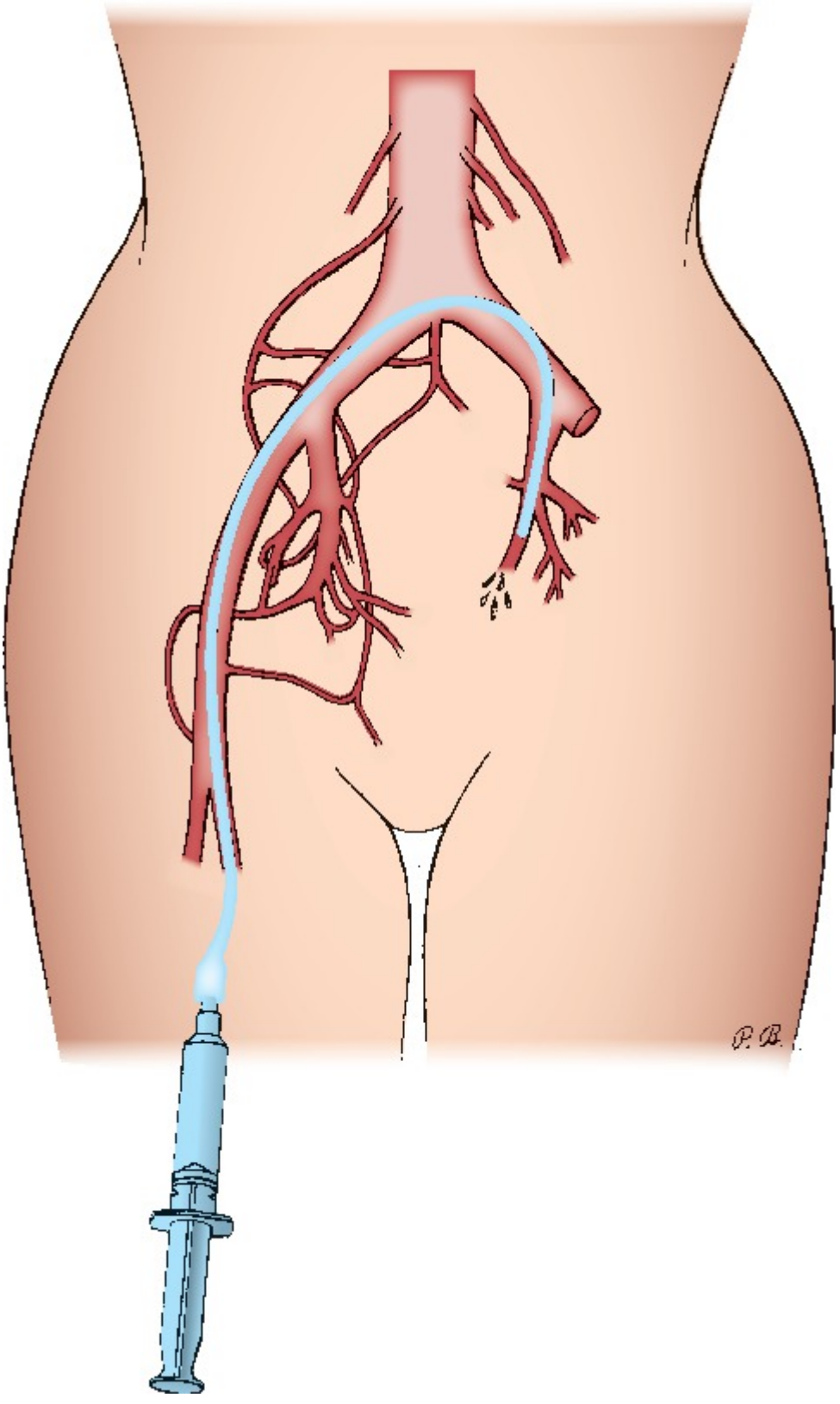

**FIGURE 39.9** The femoral artery can be catheterized under local anesthesia to provide access to the hypogastric artery and its branches.

## Use of Antifibrinolytic and Other Agents

Hemorrhage and bleeding are controlled through the fibrinolytic system. Plasmin is an important proteolytic of fibrin and fibrinogen and inhibits hemostasis. The administration of an antifibrinolytic agents such as tranexamic acid (TXA) decreases plasmin levels and promotes thrombosis. TXA competitively inhibits plasminogen activation and, at high levels, is a noncompetitive inhibitor of plasmin. TXA administration has been shown to be effective for control of trauma bleeding, bleeding encountered during cardiac surgery, and medical bleeding; there is limited data regarding the benefit of prophylactic administration. The gastrointestinal side effects of TXA (diarrhea, abdominal cramping, nausea) are not usually encountered with intravenous administration. However, hypotension can result from rapid infusion of this agent; therefore, it should be administered slowly, particularly when given in the setting of intraoperative hemorrhage when blood pressure may already be compromised.

Recombinant factor VIIa (NovoSeven RT), a recombinant form of blood factor VII originally developed for the treatment of hemophilia-related bleeding, has been reported for off-label use in cases of extreme hemorrhage. In this setting, it is administered at doses much higher than physiologic factor VIIa levels, indicating that its mechanism of action is not exclusively attributed to overcoming inadequate factor VII levels. Recombinant factor VIIa can be given either as boluses every 2 hours or as a continuous infusion. This agent is reserved for cases of catastrophic surgical bleeding when other approaches have failed.

If it is felt that surgical hemorrhage is secondary to the ongoing effects of anticoagulant therapy, pharmaceutical antidotes should be considered The effects of fractionated heparin and low molecular weight heparin can be reversed with the administration of protamine sulfate. Warfarin effects can be reversed with the administration of vitamin K. Desmopressin (DDAVP) can be given to counter aspirin-induced compromise of platelet function. The reversal of direct oral anticoagulants is more complex; however, administration of agents such as recombinant factors XA and idarucizumab can facilitate correction. These antidote therapies do not have immediate action therefore, they are most effective when used preoperatively, when hemorrhage is anticipated, rather than when significant bleeding has already commenced.

# MANAGEMENT OF HEMORRHAGE IN MINIMALLY INVASIVE SURGERY

Minimally invasive surgery (MIS) is an increasingly common approach in gynecologic surgery. It presents unique challenges in the management of hemorrhage. The steep Trendelenburg positioning required for minimally invasive gynecologic procedures allows blood from the pelvis to flow toward the diaphragm out of sight of the surgeon whose camera is typically directed in the opposite direction. When coupled with the MIS, narrow scope of vision surgeons may incorrectly assess blood loss resulting in underestimation of blood loss and delay in resuscitation. When there is apparent bleeding during a minimally invasive procedure, it is important for the surgeon to communicate with the anesthesiology staff regarding the patient's hemodynamic status to understand the degree of occult accumulated losses.

Minimally invasive surgery also presents challenges with visualization of bleeding due to lack of exposure. Exposure is limited by loops of bowel or other encroaching viscera. During brisk bleeding, use of a suction device to clear the surgical field results in loss of pneumoperitoneum, which further compromises exposure. The risk of damage to adjacent visceral structures such as the ureter

or bowel increases during these episodes of poor exposure, particularly with the use of electrosurgical devices. If visualization becomes limited to the point that it is not possible to safely appreciate or control the source of hemorrhage, the surgeon should consider immediate conversion to laparotomy.

Exposure can be improved during MIS by using laparoscopic retractor devices such as paddles or fans. These devices are deployed after insertion, offer broad retraction of abdominal contents, and are particularly effective at displacing intestinal structures. Additional ports can be placed so that surgeons can place multiple retractors and suction devices.

Laparoscopic mechanical clip appliers and Bulldog clamps are available for use in minimally invasive surgeries, just as they are for open procedures. These can be particularly useful given that laparoscopic suturing of major vessels is particularly challenging relative to laparotomy. Additionally, use of clips can minimize the use of electrosurgery and its inherent risks of damage to adjacent structures.

If major hemorrhage occurs during minimally invasive procedures, emergent conversion to laparotomy should be initiated. The basic instruments necessary to gain swift entry into the abdomen are typically available on a standard laparoscopic tray, and surgeons should not wait for laparotomy trays or retractors to become available before starting the skin incision. There is time to request this instrumentation after the abdomen has been entered and the source of bleeding has been manually compressed. For major vessel bleeding, a vertical midline incision provides the best exposure, not only to the bleeding structure but also to tissues that may need to be isolated and mobilized for the vascular repair.

Once entry has been established, the surgeon or assistant should immediately tamponade the source of bleeding, usually with manual compression, as this is both a quick and atraumatic strategy. A self-retaining retractor should be then assembled and utilized to free up the surgeons' hands. Adequate suction devices, possibly more than one, should be introduced, and, as these canisters fill, the operating room staff should be notified to communicate measured blood loss with the surgery and anesthesia staff. Once exposure has

been established, critical adjacent structures such as the ureter and bowel wall should be mobilized free from the region in need of repair. A decision should then be made regarding the optimal method of repair, and consultation with a specialist surgeon such as a vascular surgeon may be requested.

# POSTOPERATIVE MANAGEMENT

Once the patient has left the operating room after an episode of hemorrhage monitoring must continue for ongoing bleeding, correction of metabolic and hematologic imbalances, and possible sequelae of end-organ hypoperfusion.

Admission to the intensive care unit should be considered for these patietns so they can be closely monitored in the postoperative period. Routine admission to the intensive care unit is required for patients who remain intubated and sedated following abdominal packing. However, even if the patient's abdomen has been definitively closed, the patient may remain intubated postoperatively following massive transfusions of blood products and fluids due to the potential for airway edema, fluid shifts, acidosis, and other metabolic imbalances.

Patients are at risk for developing coagulopathy associated with rapid blood loss. Disseminated intravascular coagulation (DIC) is a component of the broader syndrome of trauma-induced coagulopathy (TIC), where dilution of coagulation factors occurs after massive volume resuscitation with blood products and volume expanders. Clotting factors are diluted with crystalloid infusions and blood loss but also consumed peripherally in the form of thrombotic deposition in the microvasculature. Consequently, there is paradoxical microvasculature thrombosis with associated ongoing, unresponsive clinical bleeding. This bleeding can manifest as profuse low pressure oozing from small injuries in the tissue, such as at points of needlesticks or abraded peritoneum. The combination of microvasculature occlusion, hypoperfusion from hypotension, and decreased oxygen content from loss of red cells amplifies the effects of acidosis and end-organ damage.

Hepatic and renal function in particular are impacted by hypoperfusion resulting in shocked liver and acute kidney injury. Acute liver injury can worsen coagulopathy, and impaired renal function causing volume overload and can complicate volume resuscitation. Management of these hypoperfusion injuries are largely supportive. This emphasizes the need for adequate volume resuscitation and close monitoring in the postoperative period after a hemorrhage event.

Postoperative laboratory assessment includes complete blood counts, coagulation studies, and complete metabolic assessments. These should be drawn immediately upon leaving the operating room and sent as a stat assessment. Serum lactate and base deficit assessments are effective and sensitive measures of the extent of bleeding and shock. Serial evaluations of these labs (or selective surveillance of those noted to be abnormal) should be performed. If there is significant concern for ongoing bleeding, point of care assessments of hemoglobin and hematocrit can be easily drawn at frequent intervals in the ICU, for example, every hour or two. Otherwise, sequencing laboratory evaluations at 6-hour intervals for the first 12-24 hours postoperatively should be planned.

If not already secured in the operating room, adequate intravenous access with large bore venous catheters should be placed. Arterial lines or central venous catheters can facilitate rapid and easy laboratory blood draws as well as provide the central monitoring required to assess the adequacy of volume resuscitation. Central venous catheter access is necessary for possible administration of cardiac ionotropic drugs and pressors, which may be necessary in management of shock.

In addition to frequent laboratory testing, the patient should undergo frequent physical examinations by the surgeon or surgical team. The abdomen should be examined for evidence of distension, which might suggest ongoing bleeding. Any drains left in the abdomen should be observed for the volume and consistency of contents, as this may also indicate ongoing bleeding. The extremities should be assessed for the evidence of perfusion. This is particularly important for patients who have undergone repair of a major arterial structure and who are at risk for occlusive vascular thromboses.

If patients have been transferred to the intensive care unit with an open abdomen that is packed, return to the operating room takes place after the patient has been medically stabilized and adequately volume resuscitate. Typically, patients return to the operating room at 48 hours after the initial surgery for removal of the packing, assessment for ongoing bleeding and surgical repair, and abdominal closure.

# CONCLUSION

Hemorrhage is a risk that is associated with all surgical procedures. All surgeons should be prepared to manage surgical hemorrhage. Preparation includes knowledge of the full repertoire of surgical management as well as the optimal approach to resuscitation, best way to communicate with surgical team, and postoperative care.

## KEY POINTS

- Procedural preparation is important and begins with communication with key operating room stakeholders such as the operating room nursing and anesthesiology teams.
- Excessive use of monopolar electrosurgery can result in unintentional thermal injury to adjacent structures.
- Topical hemostatic agents are expensive and surgeons should reserve their use for cases of persistent bleeding rather than apply these as a routine prophylactic measure.
- When used as an adjunct in surgery, use of cell savers and autologous transfusions can minimize the quantity of allogenic blood transfusion. The key to effective use of a cell saver is anticipation of its potential need.
- When faced with hemorrhage, it is important to avoid surgical interventions such as blindly placing sutures or excessive use of electrocautery, which unintentionally increase the bleeding or cause injury to adjacent structures.

- Application of pressure to the injured vein is the first step to controlling venous bleeding.
- Arterial ligation results in decreasing vascular pulse pressure, thus controlling downstream bleeding. This approach is a therapeutic option when there is broad surface bleeding from multiple sources of a shared supply.
- Basic principles for closing an arterial defect include making an intima to intima closure, inclusion of all 3 layers of the vessel to prevent development of arterial dissection, and prevention of luminal narrowing from over aggressive closure or by not closing the defect perpendicular to the direction of blood flow.
- When efforts to control hemorrhage with surgical intervention are not successful, it may be prudent to delay definitive repair and extricate the patient from the operating room, focus on volume and blood product resuscitation, correction of coagulopathy, and plan to re-evaluate and repair as an interval procedure. Placement of temporary packing in the surgical field applies extrinsic compression to minimize active blood loss and is extremely effective in temporizing and resolving uncontrollable hemorrhage.

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# SECTION VIII

# Surgical Management of Selected Gynecologic Conditions


40 **Surgical Management of Pelvic Pain and Endometriosis**
Matthew T. Siedhoff and Erin T. Carey

41 **Surgical Management of Pelvic Inflammatory Disease**
Matthew T. Siedhoff and Michelle Louie

42 **Surgical Management of Reproductive Tract Anomalies**
Jennifer E. Dietrich

43 **Pediatric and Adolescent Gynecologic Surgery**
Geri Hewitt

44 **Surgery for Obstetric Hemorrhage**
Jason D. Wright and Fady Khoury-Collado

# CHAPTER 40

# SURGICAL MANAGEMENT OF PELVIC PAIN AND ENDOMETRIOSIS

Matthew T. Siedhoff and Erin T. Carey

**History of Surgery and Pelvic Pain**
Pelvic Adhesive Disease
Endometriosis
**Surgery for Pelvic Pain**
**Surgery for Endometriosis**
Resection of Implants
Resection of Cul-De-Sac Lesions
Management of Ovarian Endometriomas
Resection of Rectal Endometriosis
Extirpative Resection of Endometriosis
Resection of Bladder Endometriomas
Resection of Appendiceal Endometriosis
Presacral Neurectomy
Abdominal Wall Endometriosis
Extrapelvic Endometriosis
**Resection of Ovarian Remnants**

**Uterine Suspension**

**Uterine and Adnexal Suspension to Prevent Adhesions**

# HISTORY OF SURGERY AND PELVIC PAIN

Pelvic pain has been intimately paired with endometriosis for thousands of years. Hippocrates identified four elements he believed to be strongly suggestive of benign gynecologic disease: menstrual disorders, presence of pelvic pain, association with infertility, and symptom improvement during pregnancy.

While the etiology of pelvic pain was heavily contemplated throughout the centuries, it was not until the time of autopsy that most diseases of the reproductive tract were identified. Behavioral modifications and medicinal therapies, including pain medicine, were largely used for treatment. Bloodletting in various forms was a leading therapy for centuries for pelvic and menstrual-related pain. Leech application was popularized in the late 19th century, with placement on the external genitalia, in the vagina, on the cervix, and in the uterus as a common form of treatment for endometriosis pain.

Karl von Rokitansky, an Austrian pathologist, was the first to microscopically identify endometriosis in 1860. Thomas Cullen, a 20th-century surgeon, went on to clarify the necessary histopathologic findings for the microscopic diagnosis of endometriosis: mandatory identification of endometrial glands on pathologic specimens.

Cullen suggested that women with minimal disease may benefit from less perilous surgical excision of endometriotic lesions whereas more extensive disease may benefit from hysterectomy and bilateral salpingo-oophorectomy. He also described endometriosis of the genitourinary and gastrointestinal systems and was known for performing bowel resections for deep infiltrating endometriosis.

The “father of endometriosis,” John Sampson, was inspired by Cullen’s work. He went on to introduce the term “endometriosis” in

place of “adenomyomas” in a pivotal 1927 paper. Also, notably described in the same literary journal, was his theory of retrograde menstruation and the subsequent resultant ectopic endometrium in the abdominopelvic cavity.

The transition from laparotomy to laparoscopy occurred late in the 20th century, though the first laparoscopic surgery was performed on patients in 1910. The advent of laparoscopy was particularly welcomed by those treating pelvic pain, as it afforded a diagnostic procedure without the morbidity of a laparotomy. This was initially met with a great deal of excitement because conditions such as endometriosis and adhesions could be diagnosed and eventually treated in a minimally invasive fashion. Over time, providers treating chronic pelvic pain have learned to put these conditions within the broader context of centralized pain conditions.

## Pelvic Adhesive Disease

Pelvic adhesive disease is a known complication of abdominopelvic surgery but can also occur from inflammatory conditions of the pelvis, specifically infection and endometriosis. Adhesion formation has been associated with small bowel obstruction, infertility, high surgical difficulty at time of reoperation, and chronic pain.

Treatment of adhesions as a primary cause of chronic pain is complicated. The decision to proceed with surgical intervention requires a careful measure of risk and benefit, as surgical intervention alone may result in additional adhesion formation. A recent systematic review evaluated surgical outcomes between laparoscopic or an open approach for adhesiolysis in patients presenting with adhesion-related small bowel obstruction. A total of 38 927 patients across 18 comparative studies were evaluated, and laparoscopic intervention was associated with less morbidity and mortality and fewer surgical site infections.

Dense adhesive disease, specifically vascular lesions associated with bowel adhesions, is a significant source of pain. A recent systematic review and meta-analysis evaluated the role of surgical treatment of adhesion-related chronic pain after gynecological and general surgery. A total of 13 studies were included in the review.

Laparoscopic adhesiolysis was found to reduce pain in ~70% of patients immediately postoperatively; however, there are minimal data to support long-term pain relief. One randomized trial with 12-year follow-up actually showed worse outcomes with laparoscopic adhesiolysis compared with diagnostic laparoscopy alone.

# Endometriosis

Endometriosis affects ~10% of reproductive-aged women and is frequently identified in women with chronic pelvic pain. Traditionally described as only a nociceptive pain condition, endometriosis has been associated with activation of peripheral and central pain mechanisms that contribute to the chronicity of the pain complaint. Hyperalgesia of neighboring organ systems, dubbed “cross-organ sensitization,” has also been reported in animal and human models. The stage of disease does not correlate with pain severity or intensity, and persistent pain may continue despite excision of endometriosis disease or hysterectomy.

Surgical management of endometriosis improves pain and fertility outcomes. Laparoscopic evaluation and pathologic diagnosis of endometriosis remain the gold standard. When these lesions are identified, they should be treated in symptomatic patients. The manner in which lesions are surgically managed remains debated. The two most common treatment forms are ablation or fulguration of the endometriotic lesion with either electrosurgery technique or complete surgical excision of lesions. Excision of endometriotic lesions, both deep infiltrating and superficial, results in a higher level of pain relief and dyspareunia symptoms compared to ablative therapies. Extensive dissection is necessary when treating deep infiltrating disease, and the depth of disease cannot be completely gauged until normal tissue is identified. With deep disease, excision of the entire lesion results in improved symptom management.

Systematic reviews and meta-analyses have shown marginal benefit to excisional vs ablative laparoscopic treatment of endometriosis for outcomes such as dysmenorrhea, noncyclic pelvic pain, dyspareunia, and dyschezia. However, comparing these surgical strategies is notoriously difficult. In patients with minimal to

mild endometriosis, it may be difficult to assess the degree of pain directly related to the implants themselves, as well as control for the presence of centralized pain and other disorders that would not be expected to improve from laparoscopic surgery, such as irritable bowel syndrome, painful bladder syndrome, pelvic floor tension myalgia, and other causes of centralizzed pain. For patients with deeply infiltrative endometriosis, adequate surgical treatment must include excision since, by definition, the lesions extend beyond the surface of the peritoneum.

## SURGERY FOR PELVIC PAIN

Chronic pelvic pain is a unique pain disorder derived from symptom contributions across multiple pelvic sites (eg, bowel, bladder, reproductive organs, peritoneum, pelvic floor). Pain is made up of contributions from the peripheral (local tissue response from pathology) and central nervous system (abnormal pain processing in the central nervous system termed central sensitization). A defining characteristic of chronic pain is enhanced central processing from either downregulation of the inhibitory pain pathways or upregulation of the amplification pathways. Either of these deficiencies can result in magnification of the peripheral injury.

Decreasing the somatic and visceral injury should be considered, with specific efforts to lessen tissue damage. Somatically, this would be a reduction in incision size, favoring a minimally invasive surgical approach. The abdominopelvic viscera and peritoneum, innervated by the autonomic nervous system, are also subject to tissue manipulation. Good surgical technique, respect of tissue planes, and careful dissection will minimize the visceral damage of surgery.

As a surgeon, it is important to evaluate all possible sources of pain and use the history and physical examination to assess the amount of contribution from each potential pain producer. For example, in patients who have sexual pain, there may be many several pain foci, all measurably contributing to the main complaint. Identifying the location of the patient's pain narrows the etiology and directs treatment. Insertional pain during intercourse can originate from the vulvar skin, the vulvar vestibule, genital atrophy, the pelvic

floor muscles (eg, levator ani), or the nerves of the pelvis (eg, pudendal). Provoked vestibulodynia is pain of the vestibule characterized by tenderness (eg, pain with intercourse, tampon insertion, when wearing tight clothing) and treated with a combination of topical and systemic medications as well as physical and psychological therapy. For patients who fail these measures, surgical resection of the vestibule (a vestibulectomy) can offer relief. Deep dyspareunia can also result directly from the pelvic floor musculature, with radiation to the pelvis and abdomen. When the pelvic floor muscles are identified as a source of tenderness, regardless of additional diagnoses, it may be beneficial to incorporate pelvic floor physical therapy as a primary or adjunct treatment option.

Deep sexual pain can be attributed to uterine position, as retroversion can limit the amount the uterus can elevate and move out of the pelvis during arousal and deep penetration. The uterus alone can be a source of tenderness as seen in cases of adenomyosis. Deep dyspareunia can extend beyond the uterus and cervix and can present from multiple origins in the female pelvis. The presence of deep infiltrating endometriotic lesions of the uterosacral ligaments and rectovaginal septum can explain the pain felt with deep penetration. Comorbid pain disorders of the pelvis that occur with visceral pain symptoms (eg, bladder pain syndrome, irritable bowel syndrome) or from the overall hypersensitivity of genito-pelvic pain penetration disorder are other reasons for deep dyspareunia. A seemingly uniform presenting symptom of sexual pain may be a compilation of many contributing diseases, and a combination of medical, physical, and surgical therapy may be necessary for optimal treatment.

Pelvic pain management is best guided through shared decision-making models and expectation management. A comprehensive and multidisciplinary approach to treatment of pain includes medical therapy for central pain reduction, surgical intervention for peripheral disease, psychological therapy, and physical therapy.

# SURGERY FOR ENDOMETRIOSIS

The surgical treatment for endometriosis is guided by careful patient assessment, including meticulous recording of symptoms, physical findings on examination, and preoperative imaging. For example, one may suspect rectovaginal disease when patients complain of deep dyspareunia and finding tender nodularity on examination. A palpable mass should be evaluated with imaging, usually transvaginal sonography. Endometriomas have a classic appearance of “low-level echoes,” which corresponds to layering hemorrhagic material found in the invagination of endometriotic tissue collected in the ovary. Endometriomas are important to be aware of preoperatively, particularly in fertility-minded patients. Although excision results in pain reduction, it is associated with compromise of ovarian reserve.

Use of imaging is important to document the presence of endometriosis. Contrast placed in the rectum or vagina can identify surrounding fibrosis and the extent of invasion into the *serosa, muscularis, and mucosal* layers of the colon. The approach to excision will depend on the extent of invasion. A shave resection is performed for the excision of superficial lesions or nodules overlaying the rectum or rectosigmoid. While typically reserved for shallow lesions, the mucosa may be entered unintentionally, and a full-thickness repair should be anticipated. Discoid resection is performed for larger, deeper full-thickness lesions with planned entry into bowel mucosa and repair is necessary, usually using a GI stapler. Bladder endometriomas can also be detected by MRI. Depending on the experience of the surgeon, a team approach may be needed in cases of severe endometriosis. The gynecologic surgeon should be comfortable with dissection of retroperitoneal disease and adhesiolysis but may rely on assistance from colorectal surgeons and urologists for procedures such as bowel resection and ureteral resection and reanastomosis. Patients with symptoms consistent with endometriosis may be treated presumptively without surgical confirmation. The mainstay of medical therapy includes use of nonsteroidal anti-inflammatory drugs and hormonal suppression. The mechanism of hormonal suppression is the decidualization of the ectopic endometrial tissue, preventing displaced menstruation and surrounding inflammation. The most common medical therapies

include combined oral contraceptives and oral, injectable, intrauterine, or implantable progestins. Testosterone derivatives such as danazol are used less commonly because of androgenic side effects. Aromatase inhibitors and gonadotropin-releasing hormone agonists or antagonists are other considerations for treatment of endometriosis-associated pain, but their use is limited by undesired side effects of hypoestrogenism, vaginal atrophy, bone density loss, vasomotor symptoms, and mood lability. These are only partly improved by "add-back" therapy, typically norethindrone or combined oral contraceptives (**TABLE 40.1**).

## TABLE 40.1
## Medical Treatment of Endometriosis

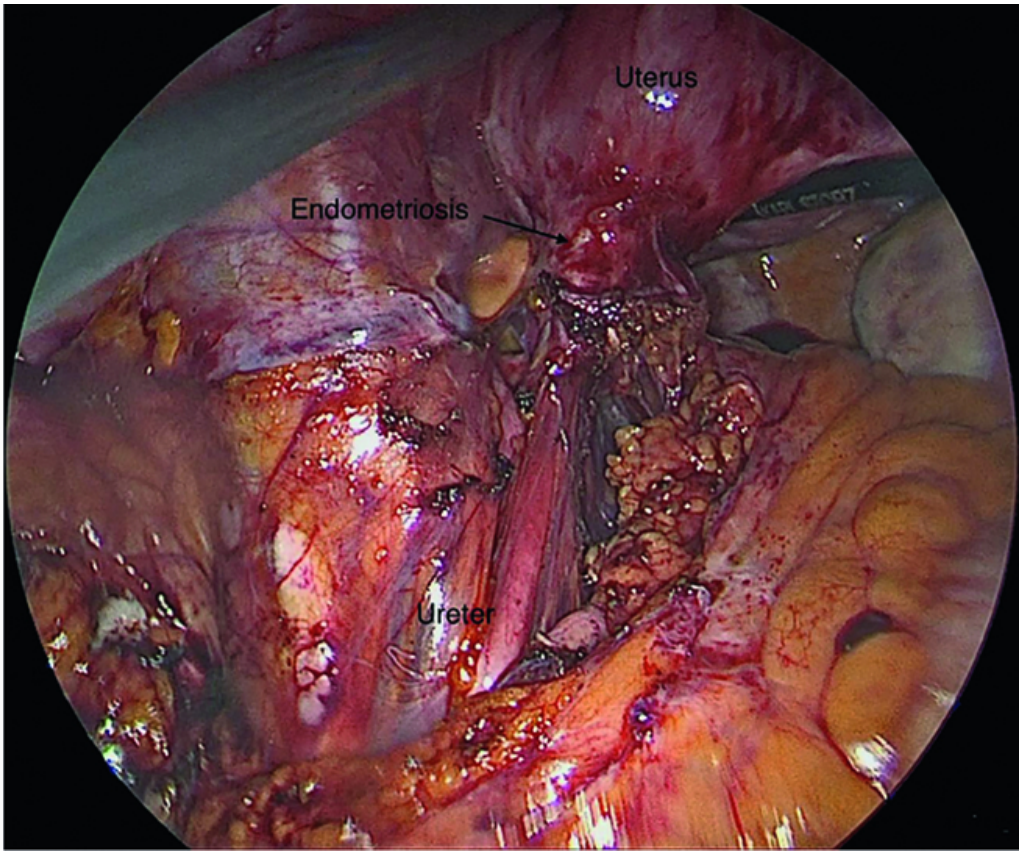
| |
|---|
| Oral contraceptives |
| Oral progestins |
| Injectable progestins |
| Intrauterine progestins |
| Implantable progestins |
| Testosterone derivatives such as (danazol) |
| Aromatase inhibitors |

Many patients will need surgical intervention due to symptoms that persist beyond symptom reduction achieved with medical treatment. The surgical approach is tailored individually to the patient based on symptoms, goals for pain and/or fertility optimization, and severity of disease. Superficial implants do not localize correlate well with symptom location and are not visible on imaging studies. There are few high-quality data to suggest that excision of these implants is favored over other methods of destruction such as fulguration and may result in improved relief of dyspareunia. Other benefits of excision include obtaining pathology for diagnosis (confirmation of

endometrial glands and stroma within the ectopic tissue), a theoretical decreased risk of recurrence, and improved fertility outcomes. It is not uncommon to see subtle changes in the uterosacral ligaments suggestive of endometriosis which, when excised and sent for pathology review, will show superficial changes overlying deeper nodular disease. Fibrotic, nodular, inflammatory endometriosis requires excision.

# Resection of Implants

To resect endometriosis implants, one must be comfortable with retroperitoneal dissection. Using monopolar or ultrasonic electrosurgery or sharp dissection, the retroperitoneal space is opened. Once the adjacent tissues have been mobilized, the peritoneum with the implant can be excised. If there are several implants within close proximity, these can be removed en bloc. When lesions overlie vital structures, the relevant avascular planes of the pelvis—pararectal, paravesical, vesicovaginal, rectovaginal, and the space of Retzius—are generously opened. If a lesion overlies the ureter, it can be mobilized with blunt dissection along its pelvic course, pushing and spreading just adjacent to the ureter rather than directly on it (**FIG. 40.1**). In a similar manner, lesions on the bladder are excised by first making a small incision in the overlying bladder peritoneum and then gently pushing the bladder downward away from the endometriotic lesion (**FIG. 40.2**). Principles for resection of endometriosis implants are outlined in **BOX 40.1**.

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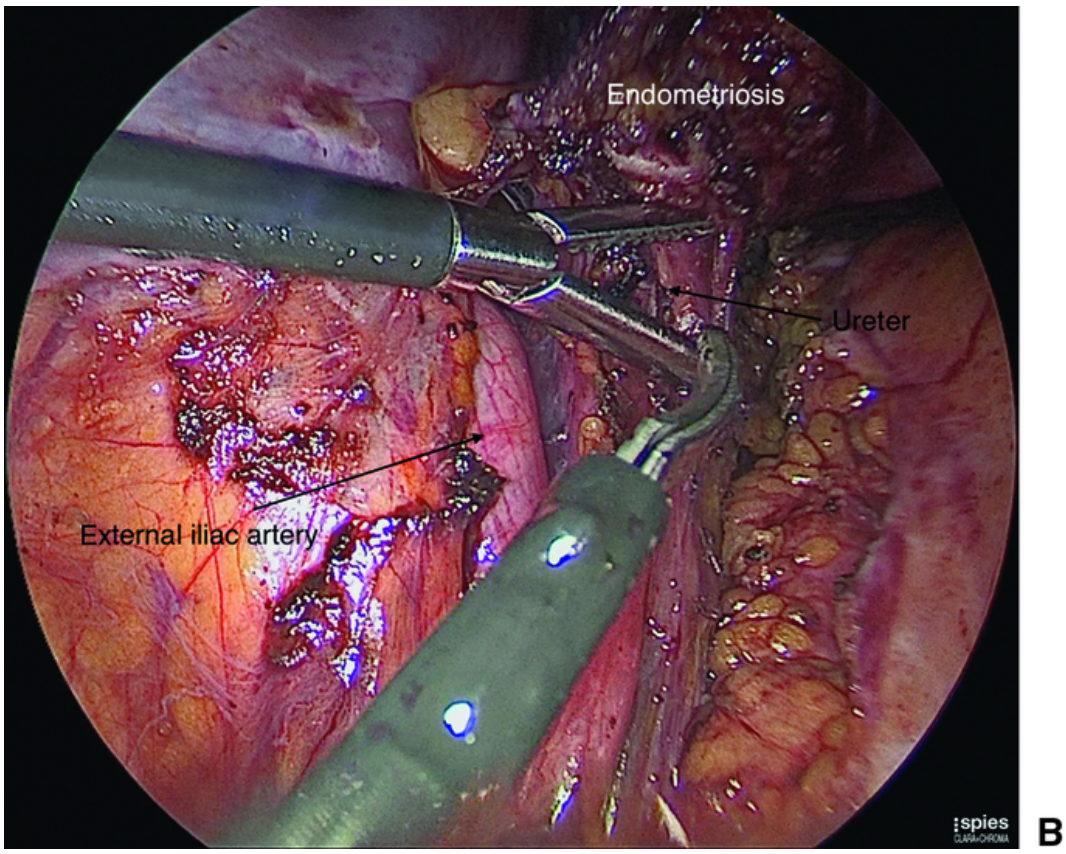
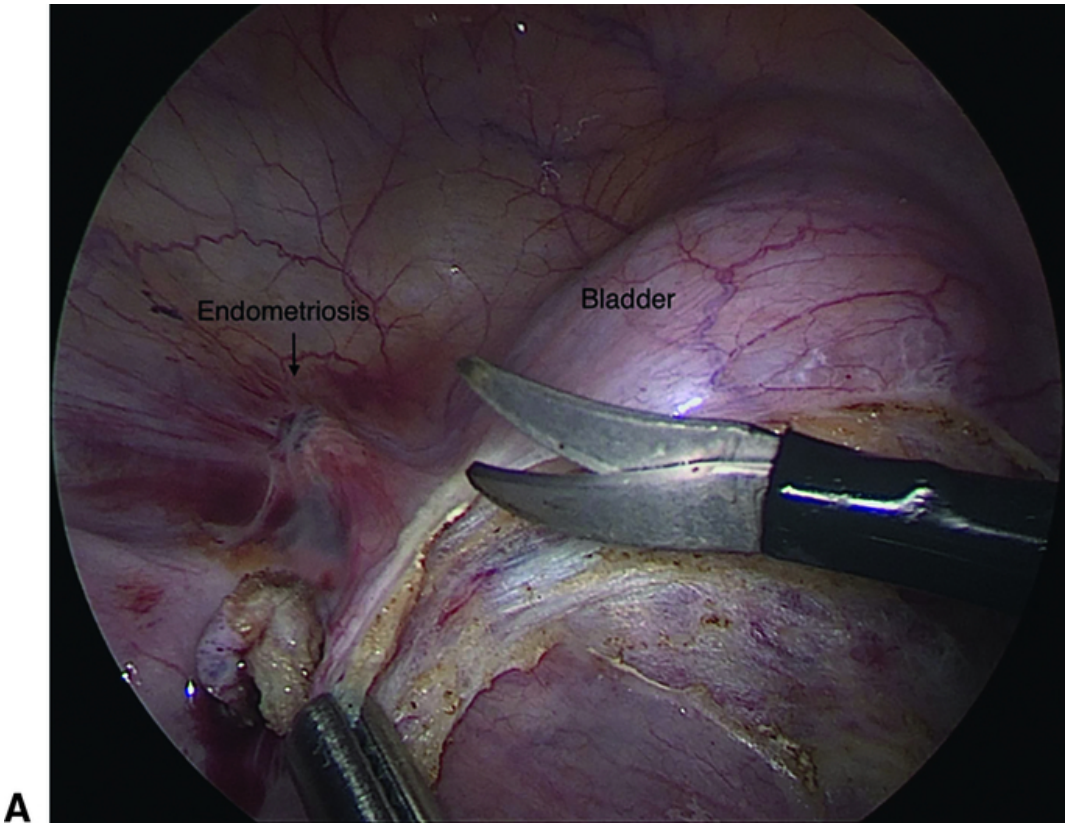



**FIGURE 40.1** **A.** Endometriosis nodule overlying the ureter. **B.** The nodule is mobilized off the ureter using a push and spread technique with an atraumatic grasper.

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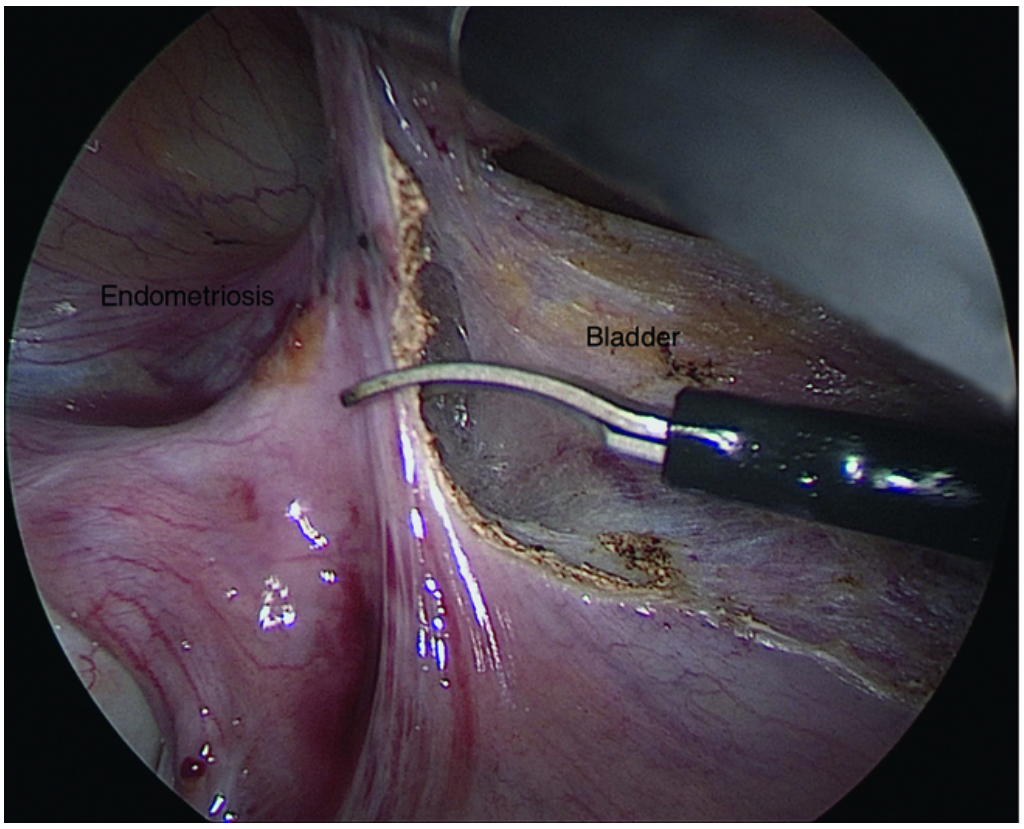



B

**FIGURE 40.2 A.** Endometriosis lesions on the bladder are excised by first making a small incision in the overlying bladder peritoneum and then **(B)** gently pushing the bladder downward away from the endometriotic lesion.

## BOX 40.1 STEPS IN THE PROCEDURE

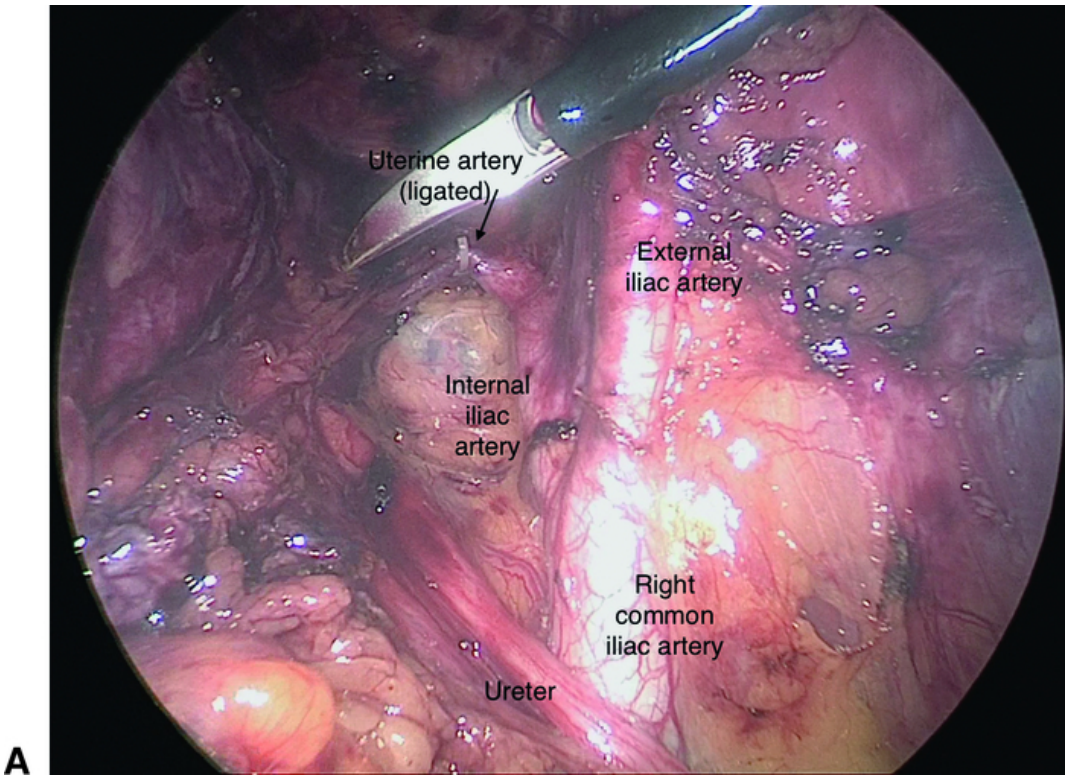
### Laparoscopic Excision of Endometriosis Implants

- Elevate and incise the peritoneum near the implant.
- Dissect retroperitoneally to provide a safe distance from underlying vital structures.
- Perform ureterolysis as needed using a “push and spread” technique.
- Excise the lesion and surrounding peritoneum with monopolar electrosurgery, with ultrasonic energy, or sharply.

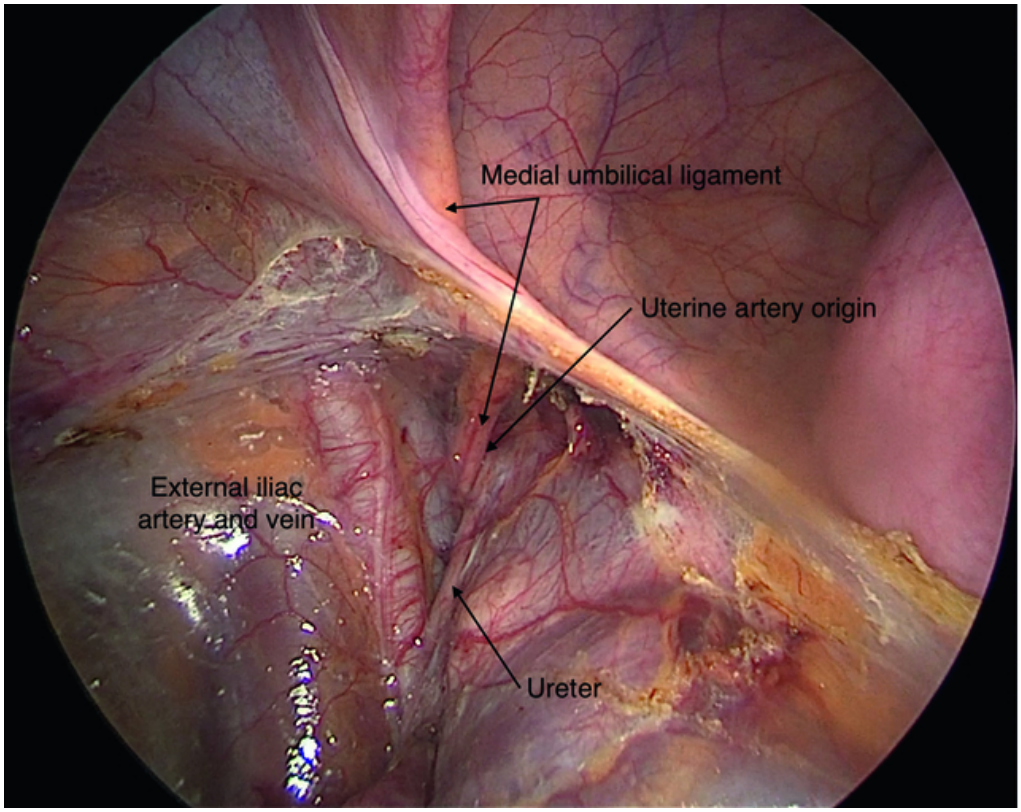
# Resection of Cul-De-Sac Lesions

For deeply infiltrating endometriosis, especially in the posterior cul-de-sac, it is advisable to open the spaces described above and dissect and identify the ureter routinely. Even in severe cases of endometriosis, the path of the ureter still follows the normal anatomic landmarks, crossing into the pelvis at the bifurcation of the common iliac artery and coursing on the medial leaf of the broad ligament before crossing under the uterine artery and entering the bladder at the trigone. Anatomic distortion of pelvic organs, however, can make the ureter adherent to surrounding structures. For example, nodularity of the uterosacral ligament can cause ureteral adhesions and ovarian endometriomas can cause the ureter to be adherent to the inferior margin of the ovary.

To excise deep cul-de-sac lesions, the pararectal space is opened with an incision lateral to the gonadal vessels. These are pushed medially, and the space is opened with a push and spread or raking technique. Again, the easiest place to locate the ureter is where it crosses into the pelvis at the bifurcation of the common iliac artery, its most superficial location. The inferior border of the pararectal space is the uterine artery coursing through the cardinal ligament. Its origin off the internal iliac can be found by following either the ureter or the internal iliac inferioposteriorly or by tracing the obliterated umbilical artery (also called the medial umbilical ligament) inferiorly along the anterior abdominal wall into the pelvis (**FIG. 40.3A and B**). The paravesical space is opened by displacing the superior vesical artery medially toward the bladder and cervical isthmus. Becoming familiar with this dissection is essential for extirpative surgery but can be helpful even in conservative resection of deep endometriosis. It is important to obtain vascular control, keep the ureter safe, and resect all of the endometriotic disease, which is often found along the cardinal ligament in addition to locations such as the rectovaginal septum **VIDEO 24.2**


Uterine artery
(ligated)
External
iliac artery
Internal
iliac
artery
Right
common
iliac artery
Ureter

A


Medial umbilical ligament
Uterine artery origin
External iliac
artery and vein
Ureter

B

**FIGURE 40.3** The origin of the uterine artery can be found by **(A)** following either the ureter or the internal iliac inferoposteriorly or by **(B)** tracing the obliterated umbilical artery/medial umbilical ligament along the anterior abdominal wall and inferiorly into the pelvis.

One of the most common locations for deep endometriosis is the posterior cul-de-sac in the rectovaginal septum. Fibrosis can extend deep into the pelvis toward the levator plate, but it usually spares the lower retroperitoneal aspect of the rectum. The majority of adhesions between rectosigmoid and uterus are usually at or just below the level of the cervix and uterosacral ligaments and extend cephalad, leaving a normal, avascular plane inferior to the adhesions. As with all endometriotic adhesions, these are best divided by first developing the normal spaces around the adhesion. The posterior cul-de-sac can be entered at the level of the uterosacral ligament and further developed by bluntly dissecting the rectovaginal space below the endometriotic adhesions (**FIG. 40.4**). The surgeon should continue developing the rectovaginal space, all the way to the levator plate if necessary, to define borders of normal tissue and find a place to divide the endometriotic adhesions between rectum and cervix above. One should avoid starting dissection through the most dense adhesions and, instead, should mobilize the surrounding avascular space first as this will clarify the correct place to sharply cut and divide the two adherent structures. Division of these adhesions should be accomplished sharply when close to the rectal tube, tolerating more oozing than one might in other locations. Once the vagina and rectum are separated, sutures or hemostatic agents can be used to stop bleeding that persists beyond pressure. Use of electrosurgery should be avoided for this purpose as it could lead to injury of rectal tissues and bowel perforation. Preemptively injecting dilute vasopressin into the uterus and cervix can decrease bleeding in this space. **VIDEO 40.1** shows excision of endometriosis,

posterior peritonectomy, resection of uterosacral nodule, and ureterolysis.

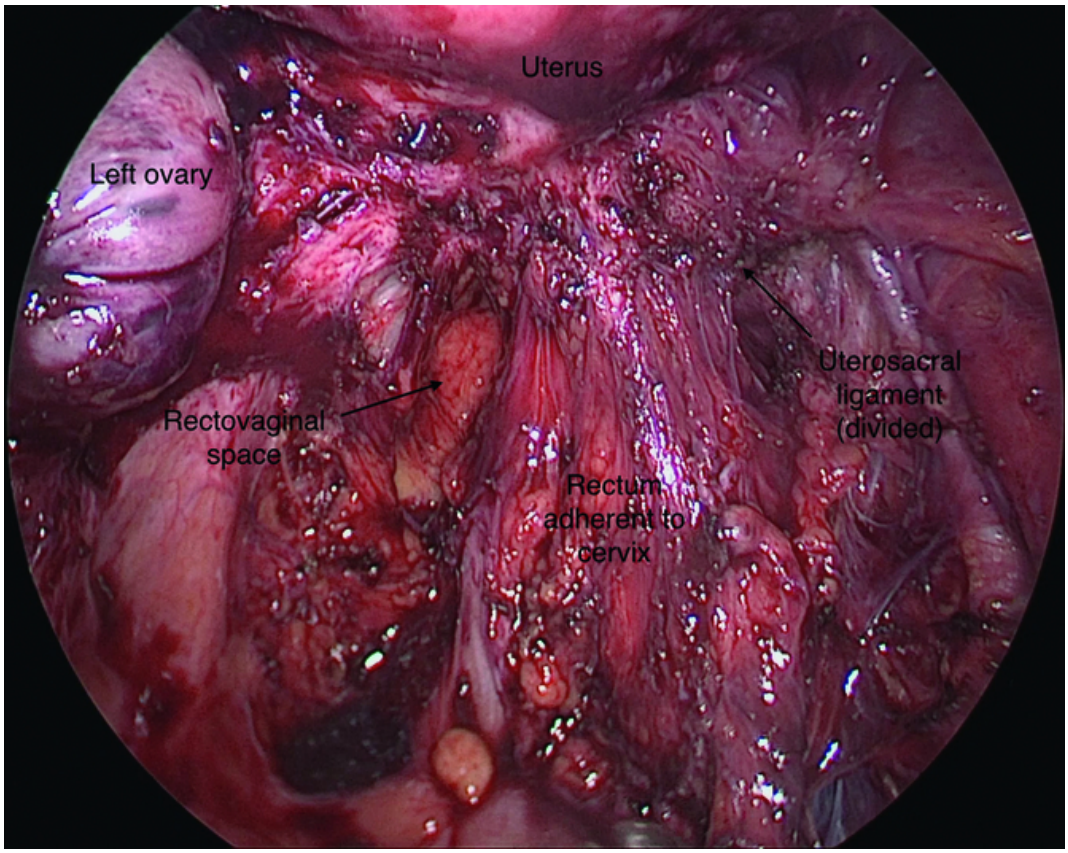



**FIGURE 40.4** Accessing the posterior cul-de-sac obliterated from endometriosis can be accomplished by dividing the uterosacral ligaments and bluntly dissecting toward the rectovaginal space, below the endometriotic adhesions.

Once the rectum is freed from the vagina, endometriosis involving the cervix and vagina can be excised with ultrasonic or monopolar electrosurgery. Sometimes it is necessary to enter the vagina to completely excise endometriosis. If a colpotomy is created, this can

be sutured closed with delayed absorbable suture, either laparoscopically or vaginally (**FIG. 40.5A and B**).

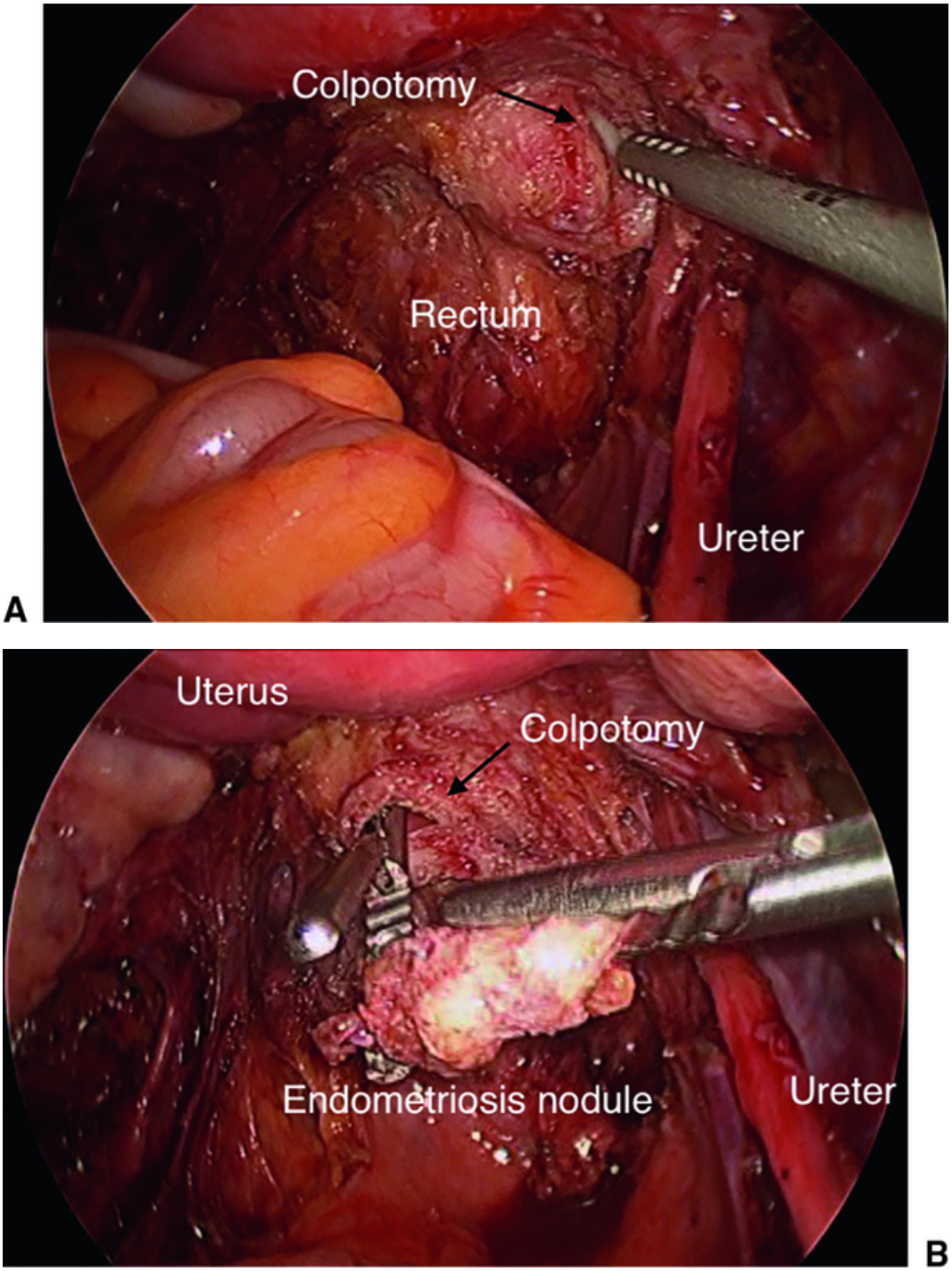
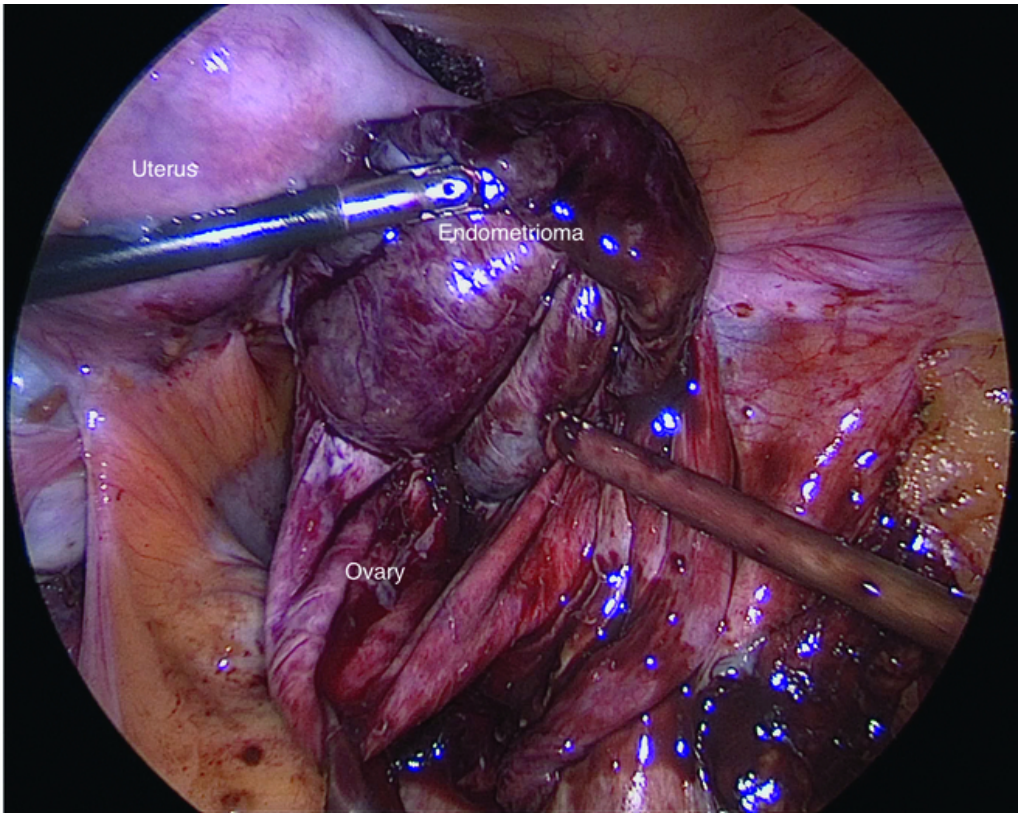


**FIGURE 40.5** **A.** A colpotomy is created to excise a deep rectovaginal endometriosis nodule. **B.** A grasper is introduced through the vagina to grasp the nodule and extract it through the vagina. The colpotomy is closed with delayed-absorbable suture.

## Management of Ovarian Endometriomas

There are many approaches to the treatment of ovarian endometriomas, including simple drainage, laser ablation, and excision. We favor excision due to the small but measurable difference in pain relief and recurrence, and associated improved spontaneous pregnancy rates. Evidence suggests the impact on ovarian reserve following endometrioma excision is less when techniques other than electrosurgery are used to obtain hemostasis. Alternative options for obtaining hemostasis include injecting the cyst with dilute vasopressin (eg, 20 units in 50-100 mL of injectable saline) before dissection and excision. Without vasoconstriction, this process can be quite bloody and make an already difficult excision more challenging due to decreased visualization. Because endometriomas are not true “cysts” with a circumferential wall similar to a teratoma, removal is always a balance of excising as much endometriotic tissue as possible without removing normal ovarian parenchyma. Endometriomas are mostly fibrotic, adherent, and vascular at their base and are even more challenging when they are multiloculated. Because they do not have a true cyst wall, they universally rupture their “chocolate” hemorrhagic material. It can be helpful to use a suction irrigator to mechanically strip the endometrioma from the ovarian tissue, clearing the brown fluid at the same time as separating the endometriosis from the rest of the ovary. Once the endometrioma is excised to satisfaction, it can be preferentially sutured to promote hemostasis, and avoid

unnecessary collateral damage to normal ovarian tissue with electrosurgery (**FIG. 40.6A and B**).

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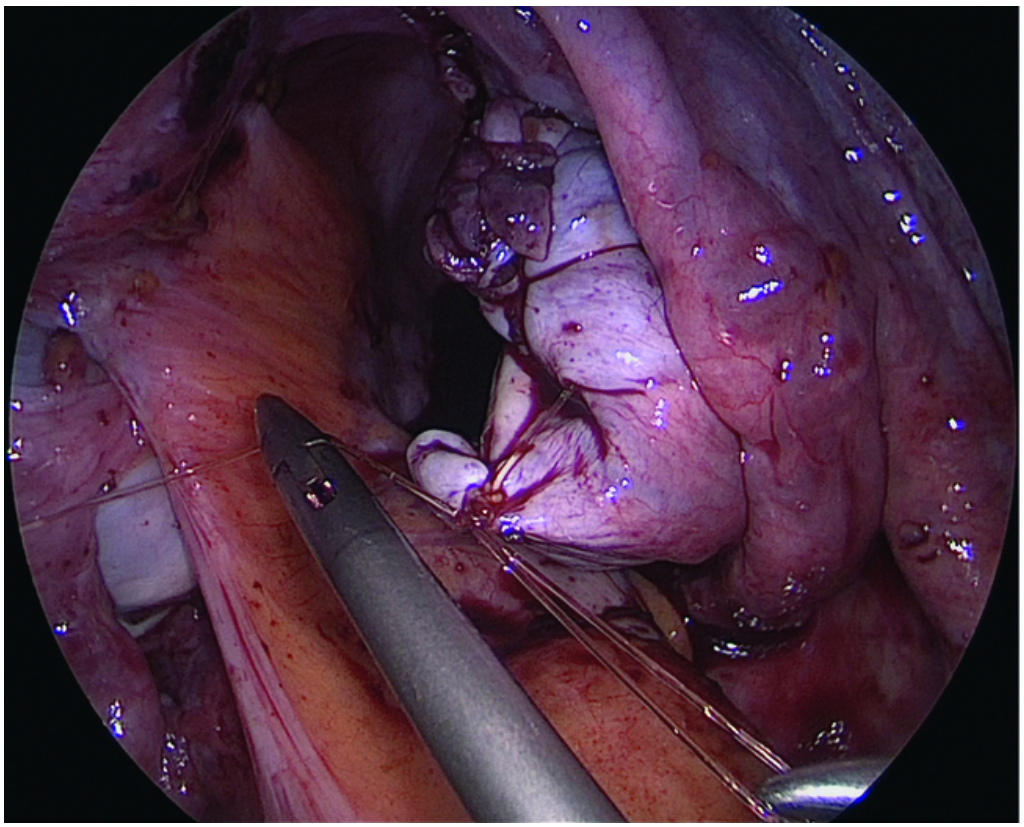



**FIGURE 40.6** **A.** It can be helpful to use a suction irrigator (*right*) to mechanically strip the endometrioma from the ovarian tissue, clearing the brown fluid at the same time as separating the endometriosis from the rest of the ovary. **B.** Once the endometrioma is excised, it can be sutured to promote hemostasis. It is important to avoid electrosurgery to prevent unnecesary collateral damage to the remaining ovary.

# Resection of Rectal Endometriosis

Endometriosis of the rectum varies in presentation and includes a few adhesions between rectum and cervix, nodular disease involving the outer serosa of the rectum, disease involving the muscularis, or full-thickness disease that penetrates the rectal mucosa. The most severe of these forms of rectal endometriosis usually requires resection, either with a transanal circular stapler for smaller lesions or by segmental resection for larger ones. Most gynecologic surgeons will operate with a colorectal surgeon in these cases. For endometriosis involving only the superficial layers of the rectum, either shaving or discoid resection is appropriate. In these cases, endometriosis is sharply excised until soft tissue is reached, and the defect is then closed perpendicular to the incision so as not to constrict the lumen. The deeper layer is closed with interrupted delayed absorbable sutures, and the superficial layer is closed with imbricating stitches of the same material or permanent suture such as nylon. There is now ample evidence that barbed suture can be used for these repairs. A single layer of delayed-absorbable barbed suture can be used for both the deep and imbricating layers.

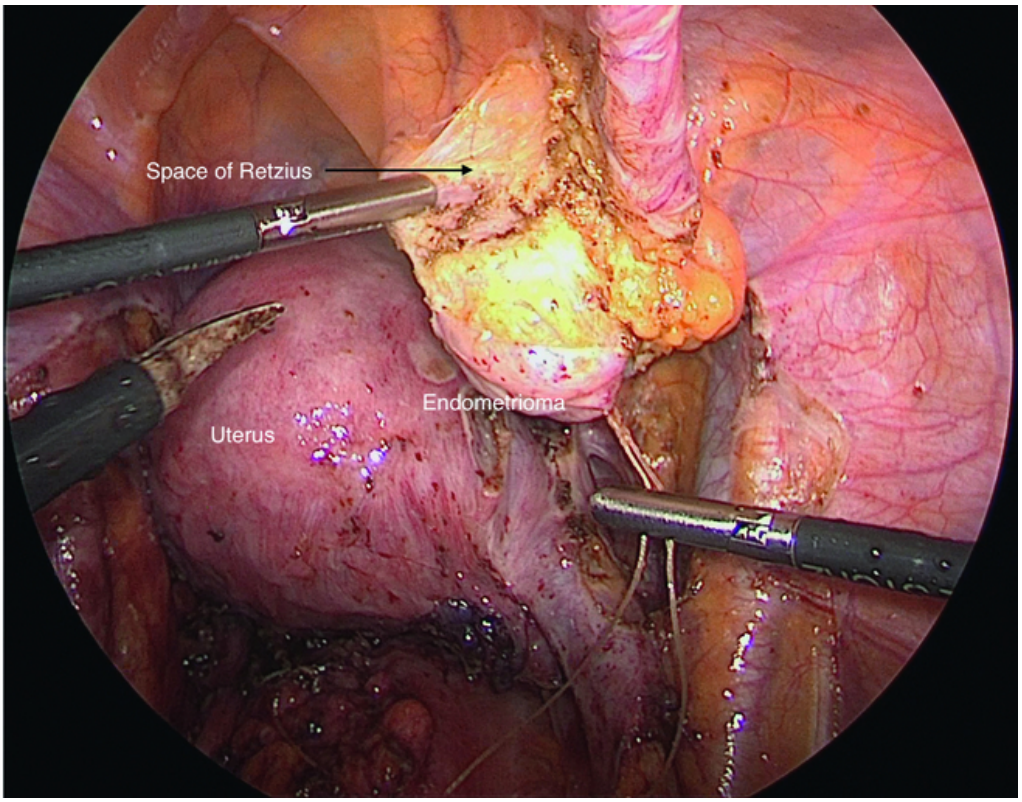
After a rectovaginal dissection or resection is undertaken, a “bubble test” is performed to check the integrity of the bowel and anastomotic site. The patient is placed in a level or reverse-Trendelenburg position, and the pelvis is filled with sterile irrigant. The sigmoid is occluded at the sacral promontory by manual compression using a hand or instrument, and air is introduced through the anus to fill the rectosigmoid. This can be accomplished using an Asepto bulb syringe or a rigid sigmoidoscope. An air-filled rectosigmoid will float in the fluid like a tire inner tube dunked under water. If bubbles emerge, there is a rectal leak. The defect should be located and closed and the test repeated to be sure the rectum no longer leaks air.

# Extirpative Resection of Endometriosis

When performing extirpative endometriosis surgery, removal of endometriosis and additional organs, the same potential spaces are developed, but vascular control is established early by ligation. At times, adnexal endometriosis can completely fill and distort the pararectal and paravesical spaces, but if the surgeon dissects sufficiently cephalad, free gonadal pedicles can be identified and ligated. On the left, the sigmoid is mobilized along the white line of Toldt, well above the pelvis into the abdomen. The left ovarian vessels can then be identified and ligated at the level of the aortic bifurcation. The ureter is also most easily identified here because it is at roughly the same depth as the external iliac artery and more superficial here than further along in its pelvic course. The remainder of the pedicle will sometimes need to be dissected from the sigmoid mesentery where it can be encased in endometriotic adhesions. The uterine artery can then be identified and ligated at its exit off the internal iliac by the techniques described above. These steps are usually more readily accomplished on the right because there is no interference by the sigmoid. Following ligation of the major vessels of the uterus and ovaries, ureterolysis is completed and the remainder of the pararectal, paravesical, vesicovaginal, and rectovaginal spaces are developed, saving the dense adhesions as a final step. Securing vascular pedicles first facilitates hemostasis and helps identify tissue destined for removal as it turns dusky while tissue to be retained (eg, bowel, bladder) remains well vascularized and pink.

# Resection of Bladder Endometriomas

Endometriosis can form implants on the bladder surface or create adhesions between the uterus and bladder, sometimes even as high as the fundus of the uterus. In advanced cases of bladder endometriosis, an endometrioma can form and involve the muscularis and, in rare cases, the bladder epithelium. The most common location for these bladder endometriomas is in the dome where they should be resected with a combination of electrosurgery and blunt dissection. At times, it can be helpful to mobilize the space of Retzius to better identify the borders of the endometrioma (**FIG. 40.7**). Depending on the size, the resulting cystotomy is closed in one, two, or three layers, as one would with an inadvertent cystotomy. Braided or monofilament delayed-absorbable sutures of 2-0 or 3-0 caliber have traditionally been used for cystotomy closure. As with bowel, these defects can also be closed with barbed suture.

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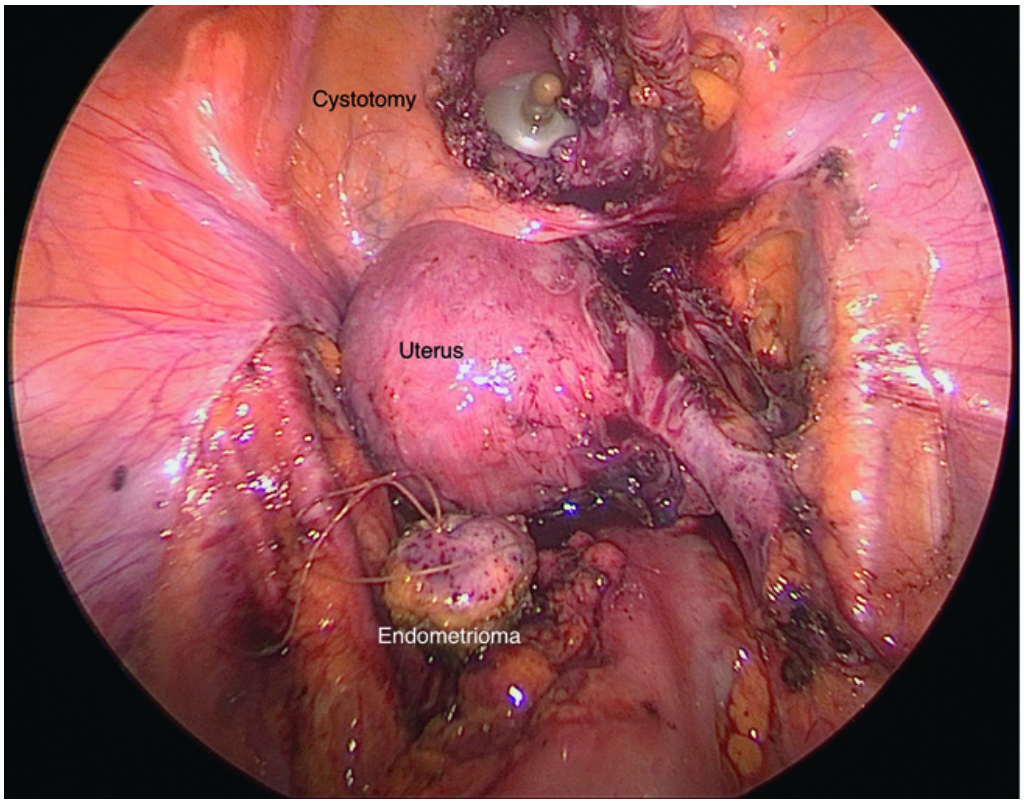



**FIGURE 40.7** **A.** At times, it can be helpful to mobilize the space of Retzius to better identify the borders of the endometrioma. **B.** The resulting full-thickness cystotomy is then sutured closed in imbricating layers of delayed-absorbable suture.

# Resection of Appendiceal Endometriosis

The incidence of appendiceal endometriosis is variable. One of the largest series included nearly 400 patients and reported that 10% of patients with any pelvic endometriosis had concurrent appendiceal endometriosis, regardless of the appearance of the appendix. For those with deeply infiltrating disease, the prevalence rose to nearly 40%. The clinical impact of endometriosis involving the appendix is unknown, but it stands to reason that if removal of implants elsewhere reduces pain symptoms, the same is likely true when implants involve the appendix. Further, there are times when the inflammation of severe appendiceal endometriosis can lead to bowel obstruction requiring ileocecectomy. It is unclear which cases progress to obstruction, but, given the very low risk of complications associated with appendectomy, removing the appendix routinely at the time of surgery for endometriosis might prevent problems associated with subsequent development of appendiceal endometriosis. Many patients with endometriosis have acute exacerbations of chronic pain that can be confused with the symptoms of appendicitis as well. Appendectomy at the time of elective endometriosis surgery can also eliminate a diagnosis of appendicitis from the differential diagnosis of pain in the future.

Appendectomy performed at the time of surgery for endometriosis is technically easier than resecting an appendix in the setting of appendicitis. In the presence of endometriosis, the appendix can be difficult to locate and separate from surrounding structures when fibrotic adhesions are present. The appendiceal tip can also be adherent to the right adnexa or deep in the cul-de-sac to the right uterosacral ligament (**FIG. 40.8**) or the nearby cecum. Care must be taken to sharply release the appendix in these cases. Once it is mobilized, it can be brought into the pelvis and the appendiceal artery divided in the mesoappendix with monopolar, bipolar, or ultrasonic electrosurgical energy (**FIG. 40.9**). The mesoappendix is then divided from the appendix using the sealing device or by clamping, dividing, and suture ligating down to the base of the

appendix. A gastrointestinal stapler is useful in cases of acute appendicitis or ruptured appendicitis when the tissue is friable from active infection. In the absence of infection, once the appendix has been skeletonized to its base, it can easily be ligated with a delayed-absorbable pretied endoscopic loop device (eg, SurgiTie [Medtronic, Minneapolis, MN], EndoLoop [Ethicon Endo-surgery, Somerville, NJ]) and then divided with one of the energy sources described above (**FIG. 40.10A-C**). The appendix will generally fit through a 10- to 12-mm trocar directly, but placing it in a specimen bag is prudent to reduce the risk of leak of intestinal contents. If a 5-mm specimen bag is used, the associated 5-mm trocar generally needs to be removed and the appendix and its specimen bag need to be brought out directly through the port site.

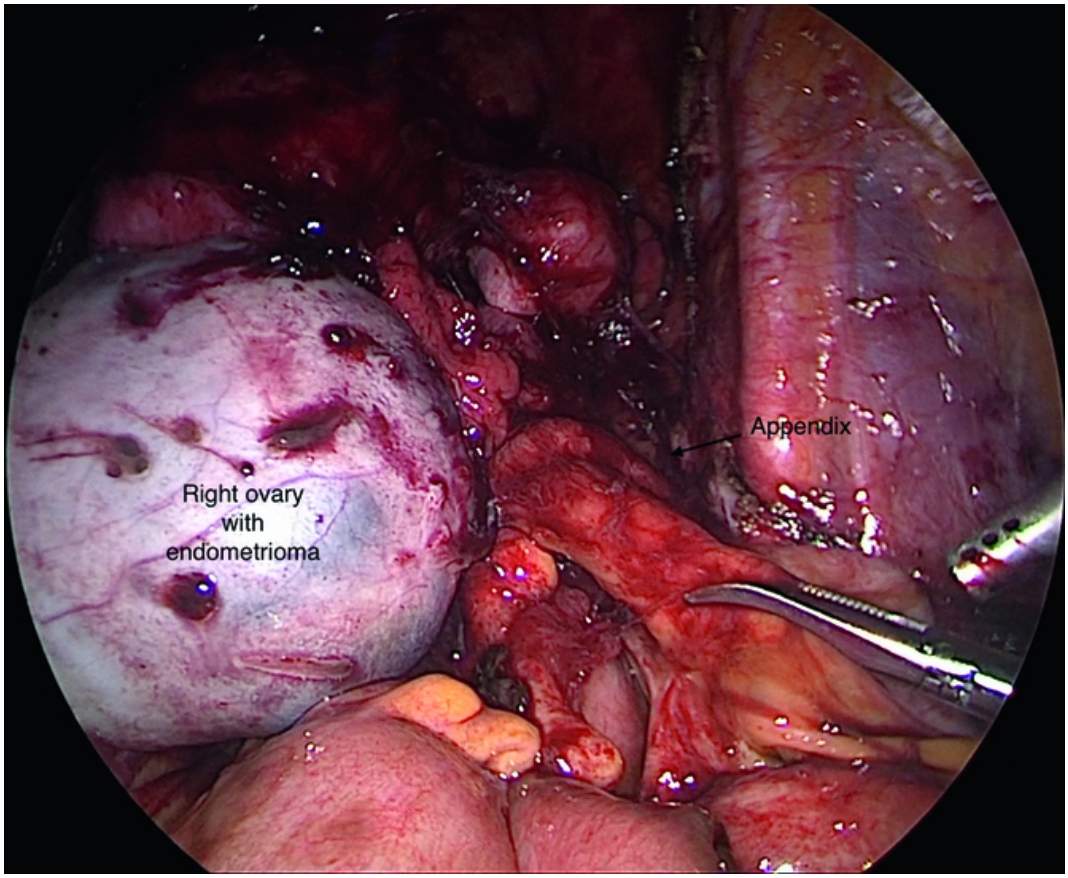



**FIGURE 40.8** With endometriosis, the appendiceal tip can be adherent to the right

adnexa. It can also be adherent deep in the cul-de-sac adherent to the right uterosacral ligament or the nearby cecum. In this figure, traction on the mesoappendix with a grasper demonstrates that the tip of the appendix is adherent to the right adnexa.

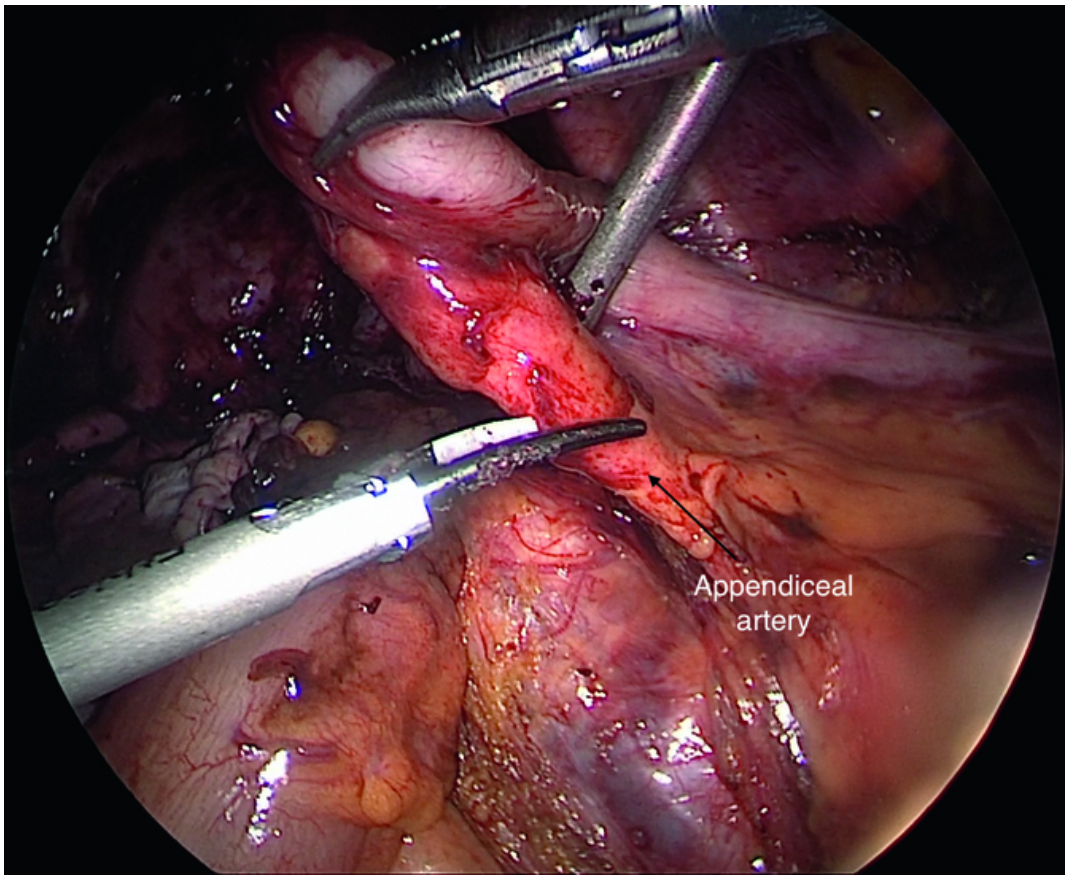
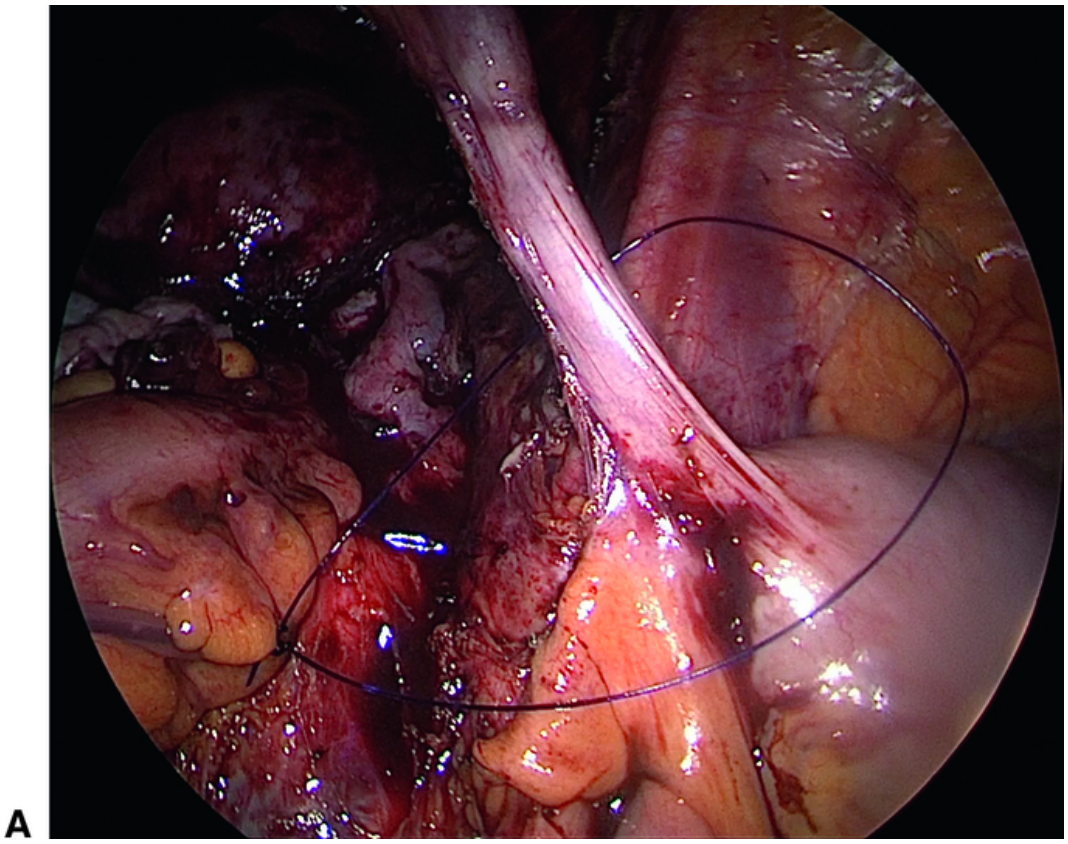



**FIGURE 40.9** Once the appendix is mobilized, it can be brought into the pelvis and the appendiceal artery divided in the mesoappendix with monopolar, bipolar, or ultrasonic electrosurgical energy.



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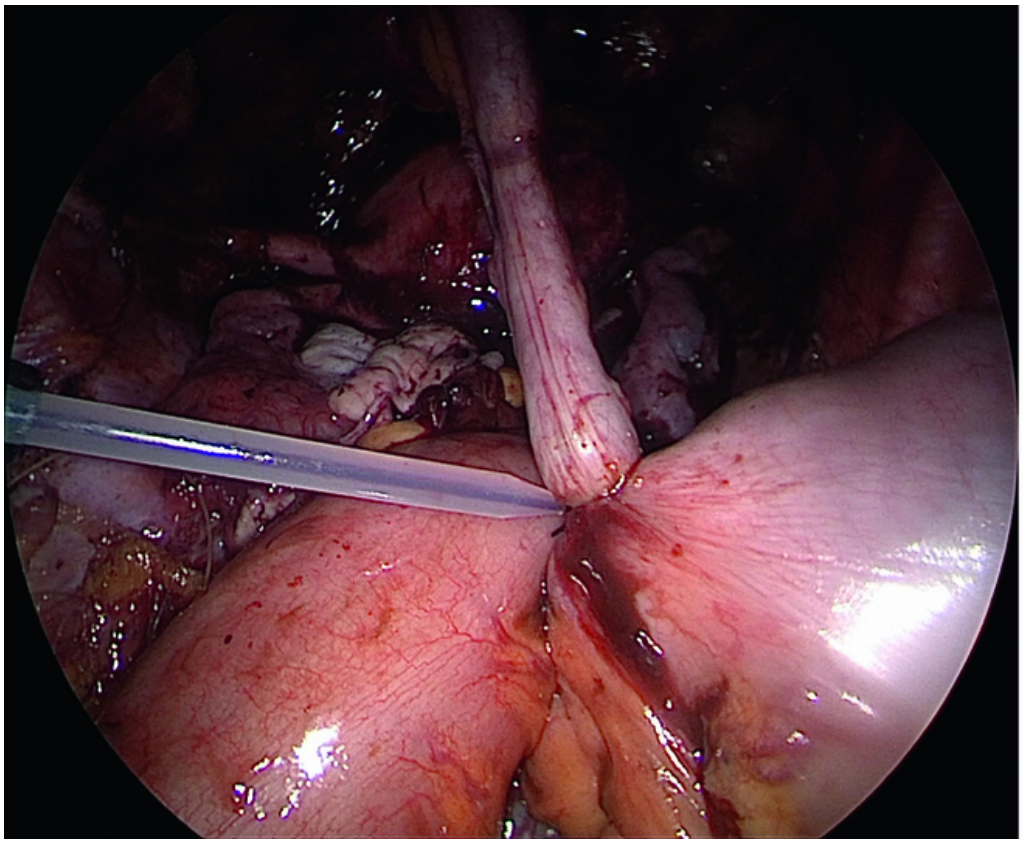

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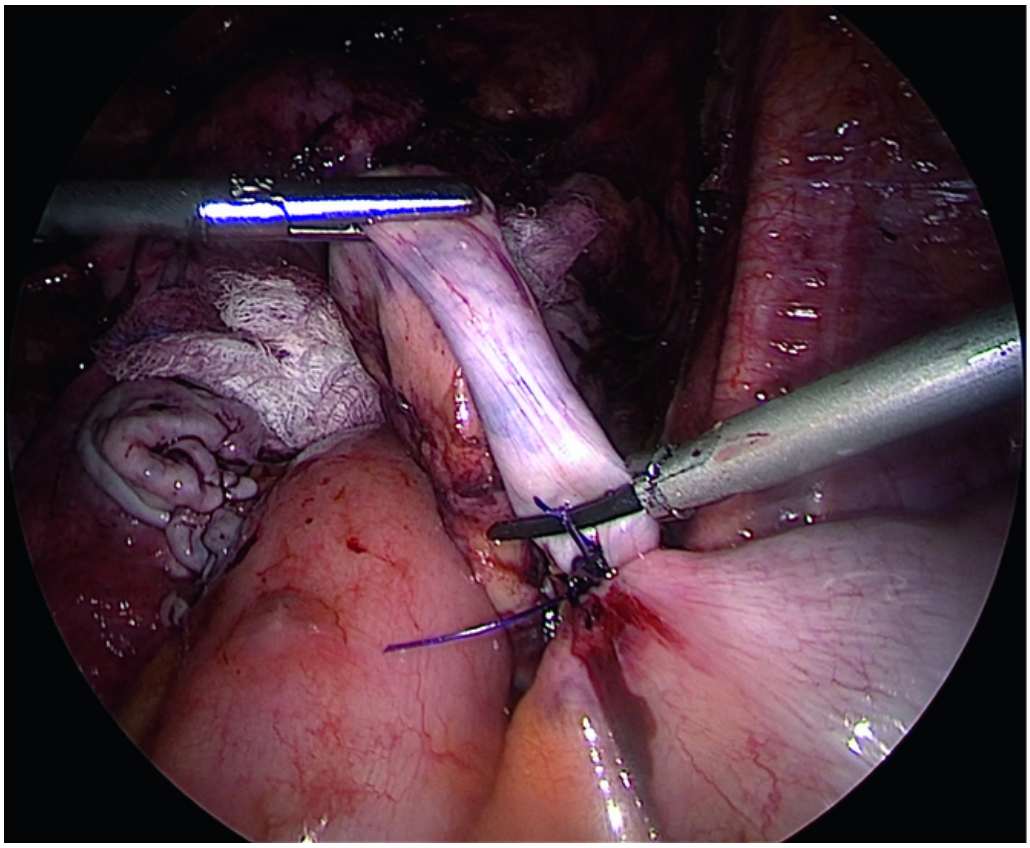


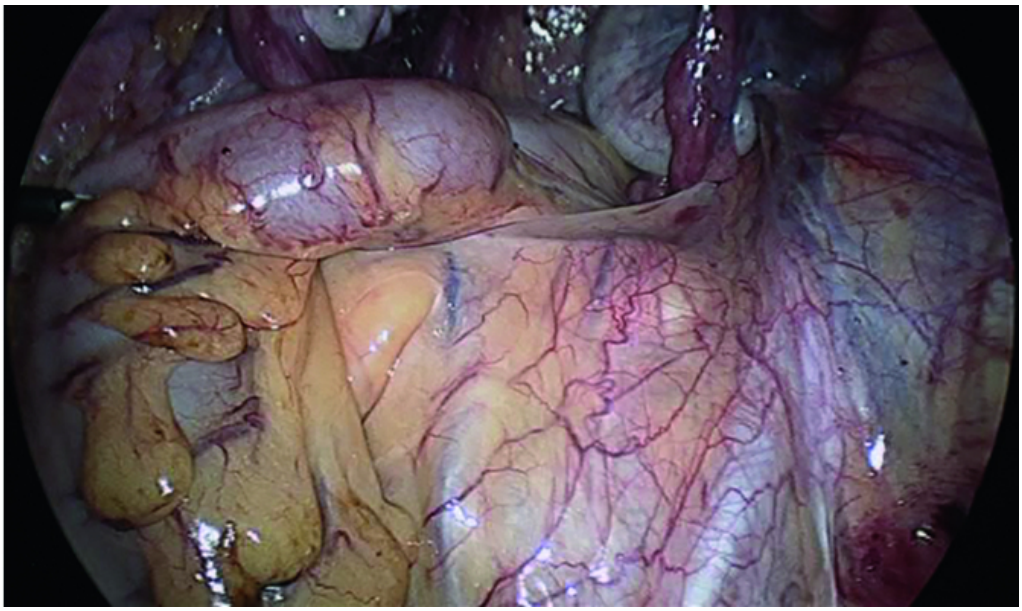

**FIGURE 40.10** **A.** The appendix is skeletonized. **B.** Ligation is undertaken with a delayed-absorbable pretied endoscopic loop device. **C.** The appendix is divided with ultrasonic electrosurgery.

## Presacral Neurectomy

Presacral neurectomy is a pelvic denervation procedure designed to target the pain-carrying afferent nerve fibers from uterus to the spinal cord. It is effective treatment for cases of midline uterine pain, uterus-associated dyspareunia, and dysmenorrhea. Perhaps the highest-quality data demonstrating its utility come from two randomized trials of endometriosis patients with concurrent midline pain. Those randomized to excision of endometriosis plus presacral neurectomy had a pain benefit durable up to 2 years following

surgery. For patients unable to use hormonal treatment for endometriosis, due to medical contraindications, previous failure, or desire to actively conceive, presacral neurectomy can effectively decrease pain symptoms.

To perform presacral neurectomy, the sigmoid colon is retracted laterally, either by the assistant or by suturing the epiploicae and bringing the ends of the suture out through the skin (**FIG. 40.11A and B**). With the sacrum exposed, an incision is made in the peritoneum just below the aortic bifurcation, as in a colpopexy. The peritoneal incision is carried out laterally to the ureter on the right, the inferior mesenteric artery on the left, and caudad to just beyond the sacral promontory. The superior hypogastric nerve can then be identified as a bundle over the sacrum, elevated, and ligated with monopolar, bipolar, or ultrasonic energy. The nerve is resected within the peritoneal outlines created in the initial dissection (**FIG. 40.12**). The specimen should be sent for pathologic analysis to ensure nerve tissue was excised. Care should be taken to avoid injury to the left external iliac vein and middle sacral artery, although the latter is not an especially large or dangerous vessel. Injury to deeper venous sacral plexuses can cause severe hemorrhage if lacerated, and care should be taken when operating in this area (**BOX 40.2**).



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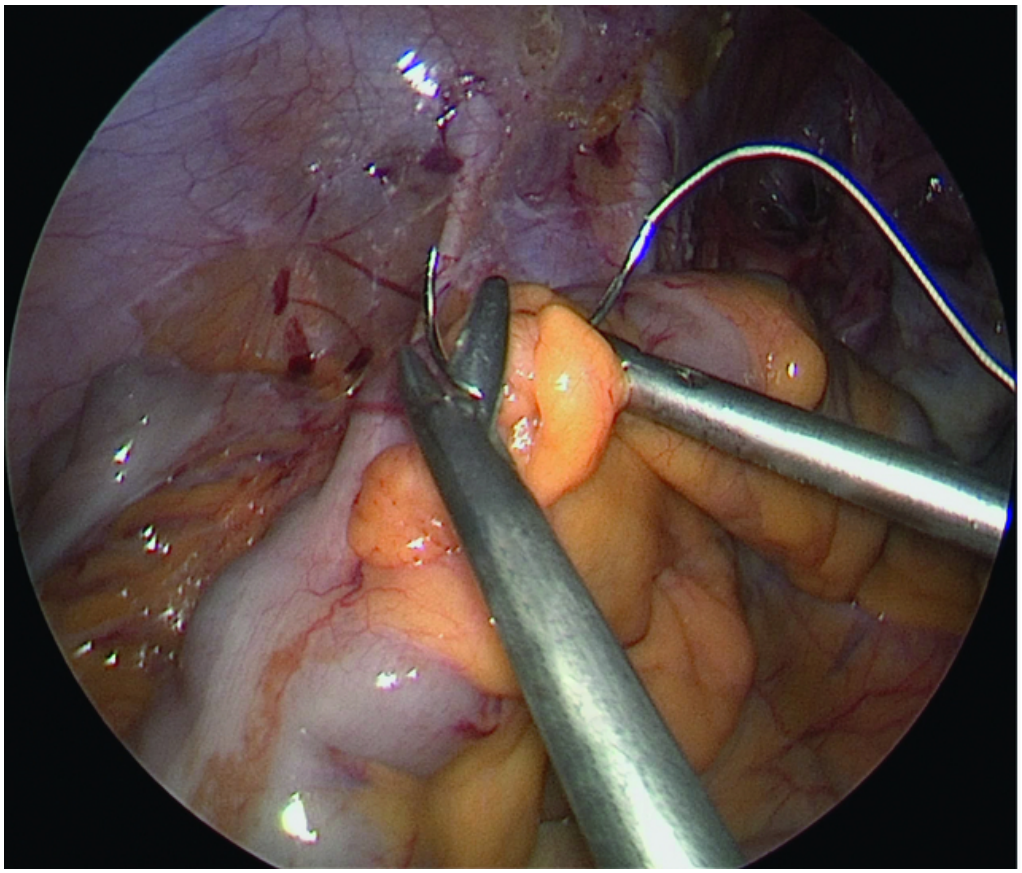


**FIGURE 40.11** The sigmoid colon is retracted laterally, either by the assistant **(A)** or by suturing the epiploicae and bringing the ends of the suture out through the skin **(B)**.

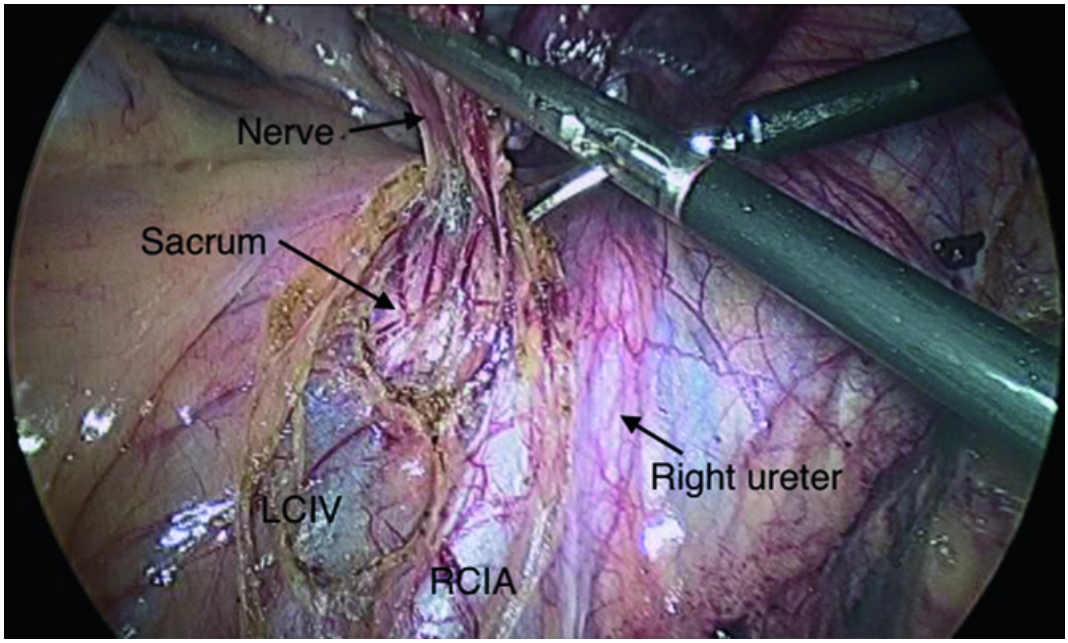


**FIGURE 40.12** The nerve is resected within the peritoneal outlines created in the initial dissection. LCIV, left common iliac vein; RCIA, right common iliac artery.

## BOX 40.2 STEPS IN PROCEDURE

### Presacral Neurectomy

- Retract sigmoid colon laterally
- Incise peritoneum below aortic bifurcation
- Extend incision to ureter on right and inferior mesenteric artery on left
- Extend incision caudad to the sacral promontory
- Identify superior hypogastric nerve and ligate with monopolar or bipolar energy
- Resect nerve and send to pathology

- Care should be taken to avoid injury to left external iliac vein and middle sacral artery

## Abdominal Wall Endometriosis

Endometriosis can also be located within the subcutaneous tissues of the abdominal wall. The usual presentation is cyclic pain associated with a tender mass, mostly commonly near a cesarean scar or the umbilicus, although these can occur in patients with no prior abdominal surgery. A skin incision is made over the nodule, within a prior abdominal incision if there is one in close proximity. The subcutaneous tissues are separated until the endometrioma is palpated. A sharp clamp can then be placed on the nodule for traction and elevation. The surrounding fat is dissected using a combination of monopolar electrosurgery and blunt dissection, rocking the mass back and forth in all directions while freeing it from the surrounding fat. It is prudent to be patient with this dissection to be sure the entire mass is excised, as they can recur if margins are not complete. If one works continuously around each aspect of the mass using electrosurgery and traction, it will begin to emerge, much as a fibroid does during a myomectomy. The borders of an abdominal wall endometrioma are fibrotic and easy to palpate, but they are not smooth like a fibroid; its edges infiltrate the surrounding fat with fingerlike extensions. Some advocate scheduling the operation for the late luteal phase of the menstrual cycle when these masses are most prominent, and one group described using computed tomography (CT)-guided needle localization to find small endometriomas in obese patients. The abdominal wall is then closed as one would for any surgical abdominal wound. For very large lesions, especially those that extend to the abdominal wall fascia, placement of mesh may be needed. For these more complex cases, coordination with a general surgeon or plastic surgeon is indicated (**BOX 40.3**).

### BOX 40.3 STEPS IN PROCEDURE

### Resection Abdominal Wall Endometriosis

- Skin incision is made over nodule; try to incise in previous incision if there is one
- Dissect subcutaneous tissue to isolate nodule
- Place sharp clamp on nodule for manipulation
- Rock nodule back and forth to free from subcutaneous fat
- Free from residual tissue using cautery or sharply
- Send nodule to pathology
- Obtain hemostasis and close abdominal wall as usual

## Extrapelvic Endometriosis

The majority of endometriosis occurs in the pelvis; however, endometriosis can be found in distant locations such as the lung, brain, abdominal wall, and thorax. When implants grow on the parietal or visceral pleura, they can manifest as isolated implants, or cystic nodules. Catamenial pneumothorax, pnemothorax occurring in a cyclical pattern related to menses, is typically treated with aspiration and/or chest tube placement. Video thoracoscopy can establish endometriosis as the cause of the collapse and aid in the resection of these endometriotic lesions. This approach is also used for repair of diaphragmatic defects and treatment of hemothorax if present. The role of pleurodesis is controversial but should be considered in the event of recurrent pneumothorax, which occurs up to a third of patients with endometriosis-related pneumothorax. Patients with hemoptysis may need bronchoscopic treatment or resection of lung endometriomas or even lobectomy in severe cases of multiple lesions.

# RESECTION OF OVARIAN REMNANTS

Ovarian remnant syndrome is characterized as the growth of ovarian tissue after a putative oophorectomy. Patients can be asymptomatic or when symptomatic will complain of unilateral pain and rarely also note a tender pelvic mass. For women who undergo presumed bilateral oophorectomy, the absence of vasomotor symptoms may signal the presence of active residual ovarian tissue. This can be confirmed by assessing follicle-stimulating hormone (FSH) and estradiol (E2) levels. For women taking hormone replacement, their medication should be stopped for 3-4 weeks before repeating FSH testing and for 48 hours prior to testing estradiol testing levels. Finding menopausal hormone levels (high FSH/low E2) in postmenopausal women does not rule out the presence of an ovarian remnant however, as not all are hormonally active. Premenopausal women with a history of unilateral oophorectomy with an ovarian remnant would not be expected to have vasomotor symptoms. Preoperatively, hormonally active remnants can be stimulated with use of clomiphene citrate, at the expense of a potential temporary increase in pain symptoms. Remnants are sometimes palpable, but more often are identified on imaging during the workup for pain symptoms. A cystic mass seen on ultrasound, CT, or MRI in the adnexal region where the patient has had a presumed oophorectomy should raise the suspicion of ovarian remnant.

Ovarian remnants are typically surrounded by adhesions and are often retroperitoneal. Retroperitoneal cystic enlargement of residual ovarian tissue within a confined space causes pain. Ovarian remnants result when the gonadal pedicle is divided very close to its connection to the ovary, leaving behind ovarian tissue or ovarian rest cells within the infundibulopelvic ligament. Risk factors for development of ovarian remnant include performing oophorectomy in the presence of adnexal adhesions, due to prior surgery, infection, or, most commonly, endometriosis. Adhesions and fibrosis surrounding large endometriomas can make it difficult to distinguish between adhesion and ovarian tissue, and the latter can be left behind in the pelvis when performing oophorectomy. Endometriomas

are also often densely adherent to surrounding vital structures such as the sigmoid colon, bladder, ureter, and uterine and iliac vessels. When resecting endometriomas in these cases, a portion of an adherent ovary may be left behind, leading to later development of an ovarian remnant.

Ovarian remnants can be avoided by performing meticulous dissection and paying careful attention to ovarian borders when removing ovaries surrounded by adhesions. The peritoneum is opened lateral to the infundibulopelvic ligament, and the pararectal space is developed. This allows visualization of the ureter and ligation of ovarian vessels distant from the ovarian hilum. In cases of dense adhesions from infection or endometriosis, the retroperitoneal dissection will require generous development of both the pararectal and paravesical spaces. Expansive development of these spaces will make it easier to distinguish endometriotic ovary from surrounding normal structures. The uterine artery and cardinal ligament may need to be sacrificed by ligation at the origin off the internal iliac in cases of deeply embedded large ovarian remnants.

A similar retroperitoneal dissection is advised when removing ovarian remnants to ensure complete excision. Ureterolysis and enterolysis are required in almost all cases, and ligation of the uterine artery will be necessary in approximately two thirds of cases. Small remnants can be difficult to identify. In these cases, finding the ovarian vessels at the level of the aortic bifurcation and following these caudally can be a helpful detection strategy. A surgeon with significant experience in these operations should pursue removal of an ovarian remnant.

# UTERINE SUSPENSION

Uterine retroversion is another reason for chronic pelvic pain manifesting as deep dyspareunia. Clearly, for many women, retroversion is an innocent anatomic variant, but for those with pain, changing the position of the uterus to an axial or anteverted position can improve dyspareunia by elevating a tender fundus out of the posterior cul-de-sac and allowing for better vaginal expansion as a natural part of the sexual response. This may be especially true for

women with posterior cul-de-sac deep endometriosis where retroversion is compounded by the coexisting inflammation and fibrosis. There are several methods for uterine suspension described in the literature. The “UPLIFT” (Uterine Positioning by Ligament Investment, Fixation, and Truncation) procedure is one of the simpler approaches. With this method, two 5-mm ports are placed in the lower outer quadrants of the abdomen. Starting on one side, the port is removed and a permanent, nonreactive monofilament suture such as polytetrafluoroethylene (GORE-TEX, W.L. Gore & Associates, Flagstaff, AZ) is introduced through the fascia with a suture passer (eg, Carter-Thomason, Cooper Surgical, Trumbull, CT). The suture passer is then advanced with the suture back and forth through the round ligament from where it exits into the inguinal canal to the uterine cornu (**FIG. 40.13A and B**). The suture is released and the suture passer removed. The suture passer is then advanced through the fascia and back and forth through the round ligament again, this time without suture. When the cornu is reached, the free end of the suture is grasped and then pulled back through the round ligament and fascia, plicating the round ligament. The ends of the suture are tagged outside the skin, and the same steps are completed on the contralateral side. With both round ligaments plicated, the ends of the suture are tied to the fascia so that the uterus is suspended equally on both sides. One should not tie the sutures overly tight since the goal is axial suspension, not extreme anteversion, and the excess tension could itself cause pain. Care should be taken to keep the knot buried below the subcutaneous tissue. Rarely the suture can cause nerve entrapment. This can be managed with local anesthetic injections or removal of the suture. Suture removal may require sedation for comfort and is generally easy to perform since the material is nonreactive. Placement of these sutures has not been shown to impact future pregnancy.

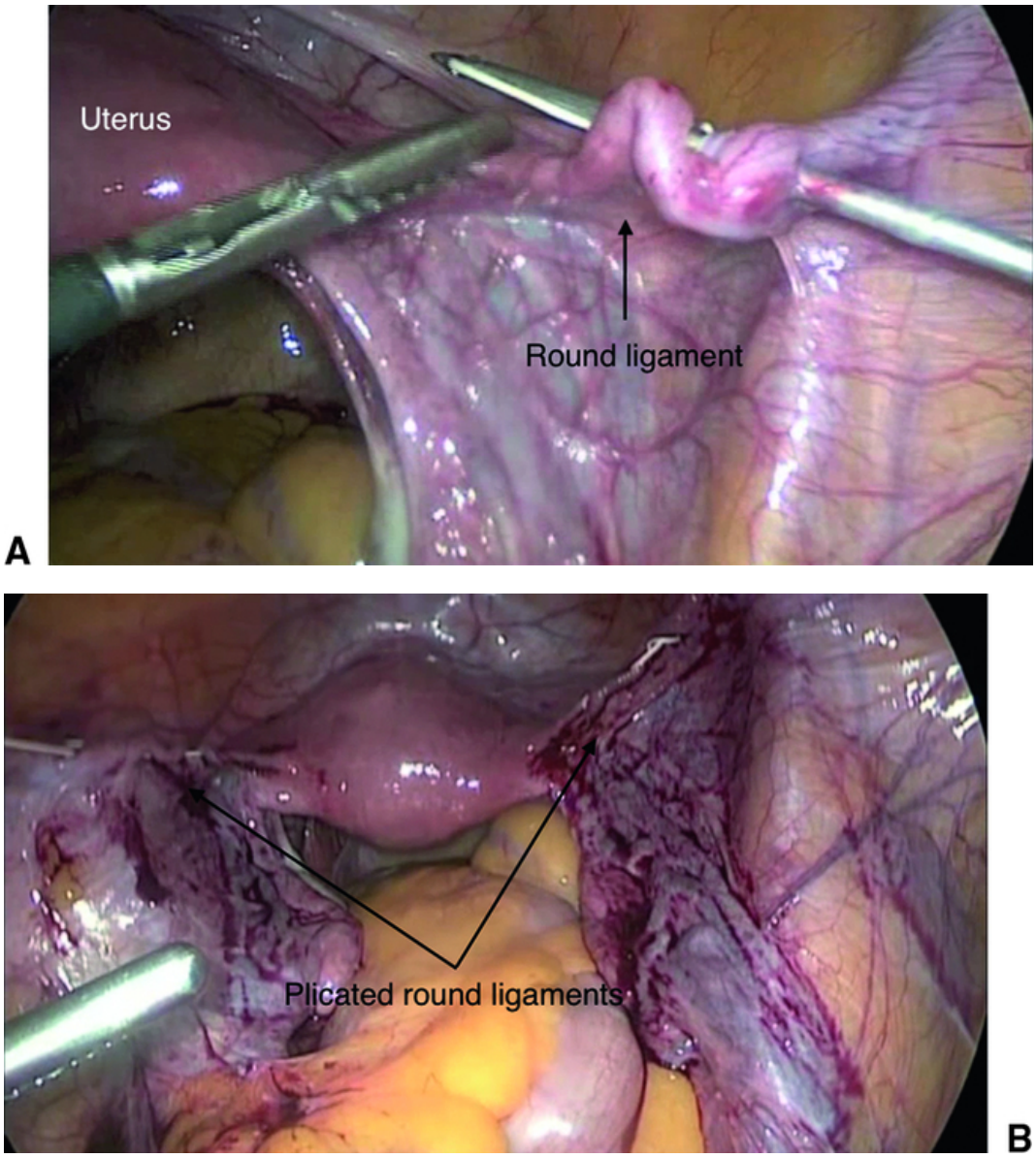


**FIGURE 40.13** **A.** The suture passer is advanced with the suture back and forth through the round ligament from where it exits into the inguinal canal to the uterine cornu. **B.** With both round ligaments plicated, the ends of the suture are tied down to the fascia so that the uterus is suspended equally on both sides.

# UTERINE AND ADNEXAL SUSPENSION TO PREVENT ADHESIONS

Placement of uterine manipulators can be useful in endometriosis surgery involving the posterior cul-de-sac, by facilitating anteversion and allowing visualization and access to this portion of the pelvis. In lieu of a manipulator, the uterus and ovaries can also be sutured to the anterior abdominal wall to provide the same exposure. A barbed suture passed through the round ligaments, ovaries, and uterus can be anchored to the peritoneum just above the cephalad margin of the bladder (**FIG. 40.14**). The suture can also be passed through the tissue and brought out through the skin using a suture passer to suspend the organs. Similarly a straight needle can be passed through the skin and abdominal wall, through the tissue to be suspended, and then back through the abdominal wall and tied. This technique is more challenging in patients with large amounts of subcutaneous tissue and a thick abdominal wall.

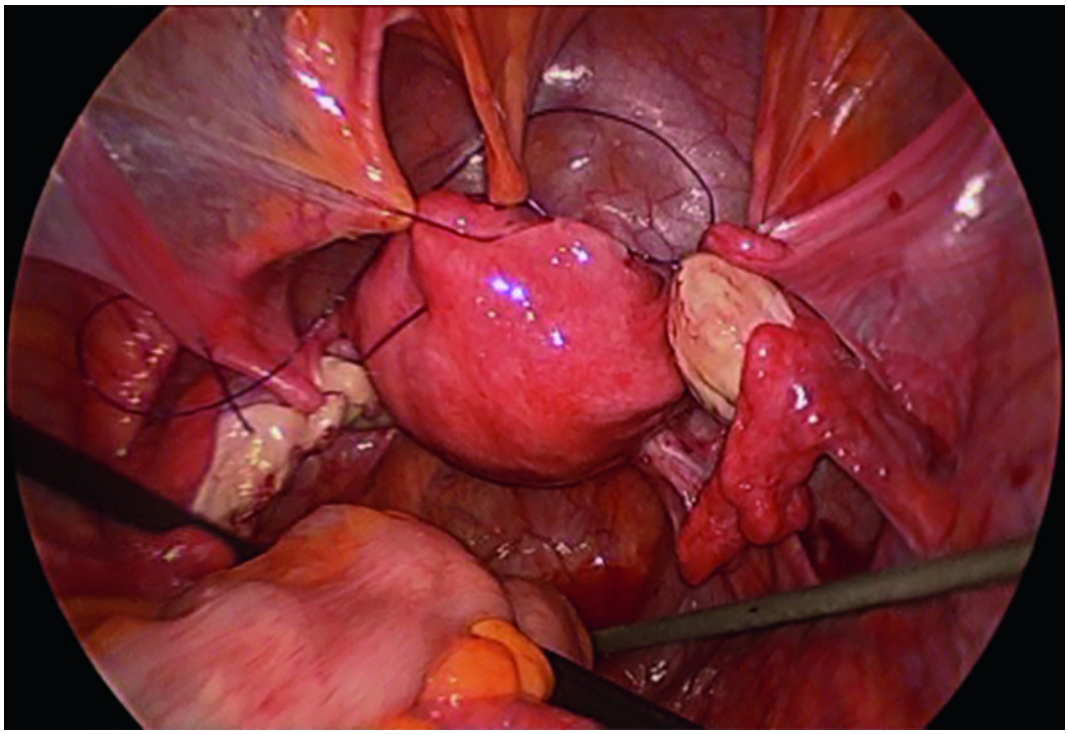

**FIGURE 40.14** A barbed suture passed through the round ligaments, ovaries, and uterus can suspend these structures to the peritoneum just above the cephalad margin of the bladder.

Some advocate maintaining ovarian suspension postoperatively to prevent adhesion re-formation in the posterior cul-de-sac following resection of rectovaginal endometriosis or ovarian endometriomas. If the suture used is brought through the abdominal wall as described before, it can be tied at the skin and then released 72 hours later after reperitonealization has occurred (**FIG. 40.15**). Another technique involves simply placing a delayed-absorbable suture through the ovary and tying it loosely to the peritoneum just lateral and above the ipsilateral round ligament. A randomized controlled trial evaluating this strategy showed that performing ovarian suspension resulted in significant reduction in posterior cul-de-sac adhesions compared to no suspension. Ovarian mobility and tenderness were measured by ultrasonographers masked to the intervention. Although there were no differences in overall pelvic pain reduction between the two groups, improvement in dyspareunia was significantly better in the ovarian suspension group.

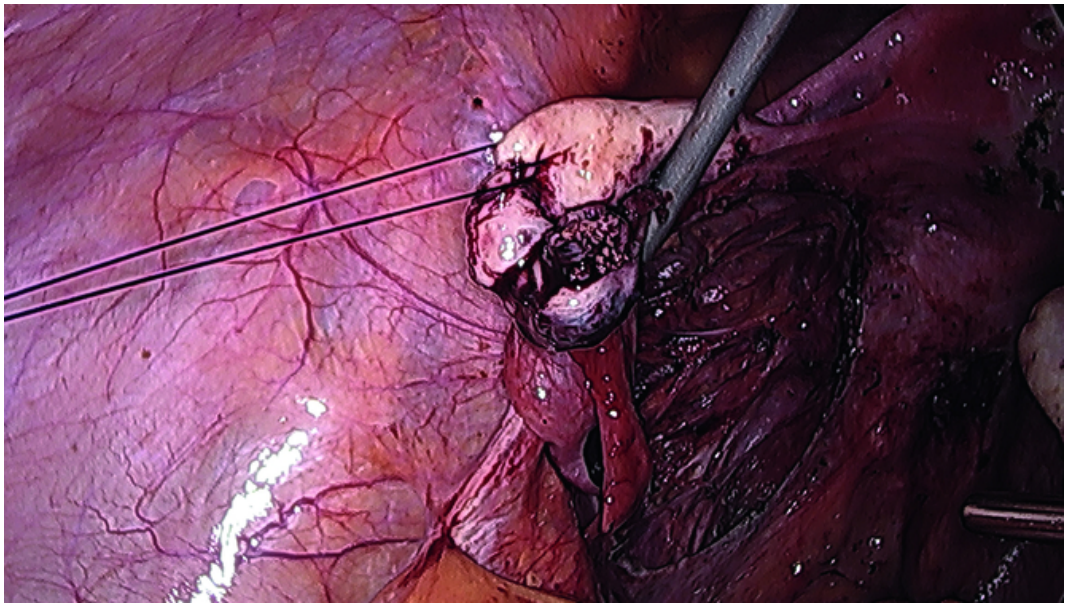

**FIGURE 40.15** To suspend the ovary, a suture is placed through the abdominal wall, through the ovary, and then back through the abdominal wall and tied at the skin. The suture is released 72 hours postoperatively. (Courtesy of Cara King, DO, University of Wisconsin.)

## KEY POINTS

- Chronic pelvic pain likely results due to a combination of pathologic peripheral generators (eg, endometriosis, adhesions) and an aberrant central processing system (amplification of pain pathways and aberrant inhibition). The choice of surgery to treat pelvic pain must be considered in this broader understanding of the etiology of patient's pain.
- Pain conditions are often multifactorial with a single patient symptom (eg, dyspareunia) having several potential explanations such as pelvic floor tension myalgia, rectovaginal

endometriosis, provoked vestibulodynia, and uterine retroversion. The decision to pursue surgical treatment of the pain symptom should be guided by the best assessment of the perceived etiology.

- Using laparoscopy preferentially for treatment of endometriosis will minimize the impact of surgical trauma.
- Surgical management of endometriosis is useful to establish the diagnosis, when medical treatment has failed, and to diagnose and treat deeply infiltrating disease.
- Excisional surgery results in better outcomes when compared to ablative techniques. When deeply infiltrative endometriosis is present, excision is the best and most effective treatment.
- Retroperitoneal dissection is required for complete excision of endometriosis. It is critical to identify underlying vital structures such as pelvic vessels and the ureter when performing this dissection.
- Presacral neurectomy is an effective treatment adjunct to excision of endometriosis in patients with a midline component to their pain.
- Ovarian remnants occur when oophorectomy is attempted in the setting of advanced endometriosis or other inflammatory conditions resulting in incomplete ovarian excision. Remnants are best prevented by performing retroperitoneal dissection and dividing the gonadal vessels distant from the ovary to ensure that the entire ovary is removed.

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# CHAPTER 41

# SURGICAL MANAGEMENT OF PELVIC INFLAMMATORY DISEASE

Matthew T. Siedhoff and Michelle Louie

**Etiology and Microbial Epidemiology**
**Risk Factors for PID**
**Clinical Presentation**
**Sequelae of Infection**
**Antibiotic Treatment**
**Percutaneous Drainage**
**Surgical Treatment**
Preoperative Planning
Intraoperative Management
**Delayed Surgical Management**
**Wound Management**
**Postoperative Care**

Each year, over 1 million women are diagnosed with pelvic inflammatory disease (PID) in the United States. One in seven women will be diagnosed with acute PID during her lifetime, and 1%-2% of young, sexually active women are diagnosed with PID each year. PID broadly encompasses any combination of

endometritis, salpingitis, tuboovarian abscess (TOA), and pelvic peritonitis. While most cases can be treated with antibiotic therapy, some will require surgical management for diagnosis, initial source control, or treatment of long-term sequelae.

# ETIOLOGY AND MICROBIAL EPIDEMIOLOGY

Pelvic inflammatory disease is a polymicrobial infection, which occurs when microorganisms from the vagina and cervix ascend to infect the uterus, fallopian tubes, or peritoneal cavity. Commonly, vaginal flora such as *Gardnerella vaginalis*, *Haemophilus influenzae*, *Streptococcus agalactiae*, anaerobic bacteria (*Prevotella*, *Bacteroides*, *Peptococcus*, and *Peptostreptococcus* species), and enteric Gram-negative rods (*Enterobacteriaceae*) are responsible for development of PID. *Cytomegalovirus*, *Trichomonas vaginalis*, *Mycoplasma hominis*, *Mycoplasma*, and *Ureaplasma* species have also been associated with PID. Fifty percent of women who are diagnosed with PID have either a *Neisseria gonorrhoeae* or *Chlamydia trachomatis* infection. Similar to bacterial vaginosis (BV), disturbance of vaginal flora leads to a loss of hydrogen peroxide–producing *lactobacillus* and overgrowth of other endogenous organisms, which may gain access to the upper genital tract. In many cases, patients may have both BV and PID; however, it is unknown if BV has a causative role in PID development or is a result of the pathogenic process.

Fifteen percent of PID cases are caused by instrumentation through the cervical mucous barrier during procedures such as intrauterine device (IUD) placement, hysteroscopy, hysterosalpingogram, and chromopertubation. Meticulous attention to aseptic technique and appropriate antibiotic prophylaxis is essential to preventing iatrogenic ascending infection. Less commonly, PID is caused by a descending infection from diverticular disease, inflammatory bowel disease, or appendiceal abscess.

# RISK FACTORS FOR PID

A history of sexually transmitted infection (STI), PID, smoking, or vaginal douching is a risk factor for development of PID. *N gonorrhoeae* and *C trachomatis* may account for up to one-half of PID cases, and the risk of PID can be decreased by screening and treating patients for these infections. Risk factors for STI include younger age, new or multiple sex partners, partners who have other concurrent sex partners, and inconsistent condom use during sex.

Genital tract instrumentation that violates the cervical mucous barrier is also a risk factor for PID. Intrauterine devices do not predispose to ongoing risk of PID, but there does appear to be a small increased risk of PID within the first 21 days following placement. Barrier methods of contraception decrease the risk and severity of PID.

# CLINICAL PRESENTATION

The most common clinical manifestations of PID are lower abdominal pain, cervical motion tenderness, or adnexal tenderness. Generally, the pain is described as recent starting <7 days prior to presentation, dull, constant, and worse with activity and intercourse. Other nonspecific complaints such as abnormal bleeding, dyspareunia, and vaginal discharge may be present with PID, whereas some patients have only subtle symptoms or are asymptomatic. The Centers for Disease Control and Prevention (CDC) specifies that one or more of the following criteria can be used to further support a diagnosis of PID: oral temperature >101 °F (>38.3 °C), abnormal cervical mucopurulent discharge or cervical friability, presence of abundant numbers of white blood cell (WBC) on saline microscopy of vaginal fluid, elevated erythrocyte sedimentation rate (ESR), elevated C-reactive protein (CRP), and laboratory documentation of cervical infection with *N gonorrhoeae* or *C trachomatis*. If the cervical discharge appears normal and no WBCs are observed on wet prep of vaginal fluid, PID is unlikely and

additional causes of pain should be considered. An algorithm for management of PID is shown in **FIGURE 41.1**.

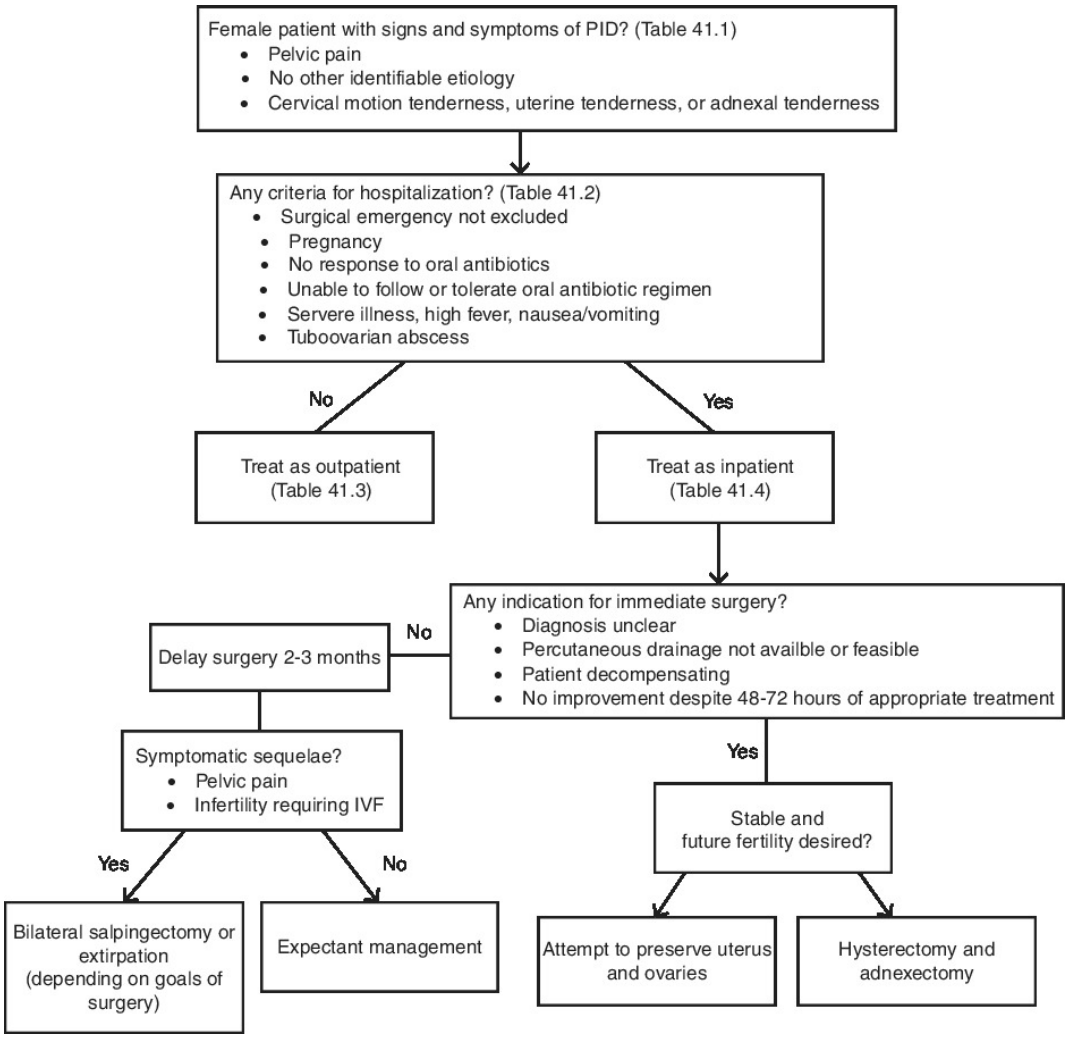



**FIGURE 41.1** Algorithm for management of pelvic inflammatory disease.

Approximately half of patients with PID initially present with normal temperature and WBC count. Signs and symptoms of systemic illness such as fever, leukocytosis, nausea, and vomiting are most common with TOA and peritonitis. TOA occurs in 10%-15% of women with acute PID. Right upper quadrant pain, pleuritic pain, and tenderness in the right upper quadrant when the liver is palpated

may be present in up to 10% of patients with PID due to perihepatic inflammation and adhesions in the setting of Fitz-Hugh-Curtis syndrome.

The most specific diagnostic tests for PID include endometrial biopsy with histopathologic evidence of endometritis; transvaginal sonography or magnetic resonance imaging (MRI) showing thickened, fluid-filled tubes, with or without free pelvic fluid or tuboovarian complex; Doppler studies suggesting pelvic infection (eg, tubal hyperemia); or laparoscopic findings consistent with PID (eg, erythema or induration of the fallopian tubes, pyosalpinx, peritubal adhesions, purulent peritoneal fluid). Most patients are treated for PID based on their clinical presentation alone, and additional tests are typically ordered when the diagnosis of PID is questionable, to assess for the presence of a TOA, or when the patient is not responding to treatment (**TABLE 41.1**).

## TABLE 41.1
## Criteria for the Diagnosis of Acute PID

Minimum criteria for diagnosis of PID:

- Patient with uterus and/or ovaries at risk for STIs
- Pelvic or lower abdominal pain
- No cause for the illness other than PID can be identified
- One or more of the following are present on pelvic examination:
  - Cervical motion tenderness
  - Uterine tenderness
  - Adnexal tenderness

The following additional criteria can be used to enhance the specificity of the minimum criteria and support a diagnosis of PID:

- Oral temperature >101° F (>38.3° C)
- Abnormal cervical mucopurulent discharge or cervical friability
- Presence of abundant numbers of WBC on saline microscopy of vaginal fluid
- Elevated erythrocyte sedimentation rate (ESR)
- Elevated C-reactive protein
- Laboratory documentation of cervical infection with *N gonorrhoeae* or *C trachomatis*

Most specific criteria for diagnosing PID:

- Endometrial biopsy with histopathologic evidence of endometritis
- Transvaginal sonography or magnetic resonance imaging showing thickened, fluid-filled tubes with or without free pelvic fluid or tuboovarian complex, or Doppler studies suggesting pelvic infection (eg, tubal hyperemia)
- Laparoscopic abnormalities consistent with PID

Modified from Workowski KA, Bachmann LH, Chan PA, et al. Sexually transmitted infections treatment guidelines, 2021. *MMWR Recomm Rep*. 2021;70(No. RR-4):1-187.

Performing a culdocentesis to ascertain whether purulent peritoneal fluid is present (with WBC count of >30 000 cells/mL) may aid in the diagnosis of PID. However, it is an invasive and painful procedure

that is not specific for PID, and cul-de-sac contents may be purulent due to other intraperitoneal infections such as appendicitis or diverticulitis. Given the availability of other highly accurate diagnostic modalities, culdocentesis should be restricted to resource-limited settings where other diagnostic tools are unavailable. If PID is suspected or confirmed, nucleic acid amplification testing for *N gonorrhoeae* and *C trachomatis*, serologic testing for HIV, and urine testing for pregnancy should be performed. All patients with PID and documented *N gonorrhoeae* or *C trachomatis* should be retested 3 months after treatment.

# SEQUELAE OF INFECTION

One in four women who have had acute salpingitis will experience one or more long-term sequelae. Due to damage of cilia lining in the fallopian tubes and peritubal and intratubal adhesions, PID can lead to infertility, ectopic pregnancy, recurrent PID, and chronic pelvic pain. The severity of tubal damage is correlated with the severity of infection, time to treatment, increasing number of PID episodes, and chlamydial infection. Up to 20% of affected women will become infertile because of PID, with the incidence of infertility as high as 85% in women with history of TOA. The risk of ectopic pregnancy is increased 6- to 10-fold in patients with a previous episode of acute salpingitis and increases with the number and severity of episodes. At least half of ectopic pregnancies occur in fallopian tubes damaged by previous salpingitis. Twenty to thirty-three percent of patients develop chronic pelvic pain after PID, which may be due to sensitization, hydrosalpinx, or pelvic adhesions. Almost one-third of patients require surgical intervention for persistent disease or pain following acute PID.

# ANTIBIOTIC TREATMENT

The CDC recommends presumptive treatment of PID for patients presenting with lower abdominal pain and tenderness on pelvic examination (cervical motion tenderness, uterine tenderness, or

adnexal tenderness) with no other identifiable cause. Because half of all cases of PID are caused by endogenous genital flora and not an STI, sexual activity is not a necessary condition for diagnosing and treating PID. Prompt and appropriate antibiotic therapy can prevent morbidity and reduce the occurrence and severity of long-term sequelae. Presumptive treatment with antibiotics is also unlikely to affect other possible causes of acute pelvic pain if the etiology is unclear or still undergoing investigation. The CDC recommends that the most recent sexual partner and all sex partners encountered 60 days before the patient's onset of symptoms should be evaluated, tested, and presumptively treated for chlamydia and gonorrhea, regardless of the PID etiology or pathogens isolated and even if they are asymptomatic. Patients should be instructed to abstain from sexual activity until antibiotics have been completed, symptoms have resolved, and sex partners have been appropriately treated and are also asymptomatic.

If a patient is assessed to be appropriate for outpatient treatment (**TABLE 41.2**), the CDC recommends empiric broad-spectrum antibiotic therapy for 14 days to cover Gram-positive, Gram-negative, and anaerobic bacteria due to the polymicrobial nature of PID. All regimens used to treat PID should also be effective against *N gonorrhoeae* and *C trachomatis* even if nucleic acid amplification testing is negative.

## TABLE 41.2
## Criteria for Hospitalization of Patients With Acute PID

- Surgical emergencies cannot be excluded.
- The patient is pregnant.
- The patient does not respond clinically to oral antimicrobial therapy within 72 hours.
- The patient is unable to follow or tolerate an outpatient oral regimen.
- The patient has severe illness, nausea and vomiting, or high fever.
- The patient has a tuboovarian abscess.

Modified from Workowski KA, Bachmann LH, Chan PA, et al. Sexually transmitted infections treatment guidelines, 2021. *MMWR Recomm Rep*. 2021;70(No. RR-4):1-187.

Inpatient antibiotic treatment (**TABLE 41.3**) is recommended based on provider judgment and if the patient fits any of the following clinical scenarios: surgical emergencies (such as appendicitis) cannot be excluded, presence of TOA, pregnancy, severe illness including nausea and vomiting or high fever, inability to follow or tolerate an outpatient oral regimen, or no clinical response to oral therapy within 72 hours. Oral and intravenous treatment with doxycycline have demonstrated equivalent clinical efficacy, and when possible, oral administration of doxycycline is recommended due to discomfort associated with intravenous administration. Metronidazole should be added for additional anaerobic coverage in the presence of TOA. If the patient has a severe penicillin allergy, an alternative regimen may be given (**TABLE 41.4**). As the risk of penicillin cross-reactivity is negligible between cefoxitin and all third-generation cephalosporins, only patients with a severe allergy to penicillin (eg, anaphylaxis, angioedema, or urticaria) should receive alternative regimens. Parenteral therapy can be discontinued 24-48 hours after clinical improvement and patients can complete 14 days of therapy after discharge.

## TABLE 41.3
## CDC-Recommended Treatment Regimen for

# Outpatient Treatment of Acute PID

| |
|---|
| Ceftriaxone 500 mg IM in a single dose (For persons weighing >150 kg (~300 lb) with documented gonococcal infection, 1 g of ceftriaxone should be administered.) |
| ***PLUS*** |
| Doxycycline 100 mg orally twice a day for 14 days |
| ***PLUS*** |
| Metronidazole 500 mg orally twice a day for 14 days |
| **OR** |
| Cefoxitin 2 g IM in a single dose and probenecid, 1 g orally administered concurrently in a single dose |
| ***PLUS*** |
| Doxycycline 100 mg orally twice a day for 14 days |
| ***PLUS*** |
| Metronidazole 500 mg orally twice a day for 14 days |
| **OR** |
| Other parenteral third-generation cephalosporin (eg, ceftizoxime or cefotaxime) |
| ***PLUS*** |
| Doxycycline 100 mg orally twice a day for 14 days |
| ***PLUS*** |
| Metronidazole 500 mg orally twice a day for 14 days |
| **Alternative Oral Regimens** (if allergy precludes use of cephalosporin therapy): |
| Gentamicin 240 mg IM in a single dose |
| ***PLUS*** |
| Azithromycin 500 mg IV daily for 1-2 doses, followed by 250 mg orally daily |
| ***PLUS*** |
| Metronidazole 500 mg orally twice a day for 14 days |
| **OR** |
| Levofloxacin 500 mg orally once daily or moxifloxacin 400 mg orally once daily for 14 days (acceptable if community prevalence and individual risk for gonorrhea are low, and if follow-up is likely) |
| ***PLUS*** |
| Metronidazole 500 mg orally twice a day for 14 days |

Modified from Workowski KA, Bachmann LH, Chan PA, et al. Sexually transmitted infections treatment guidelines, 2021. *MMWR Recomm Rep*. 2021;70(No. RR-4):1-187.

## TABLE 41.4
## CDC-Recommended Treatment Regimens for Inpatient Treatment of Acute PID

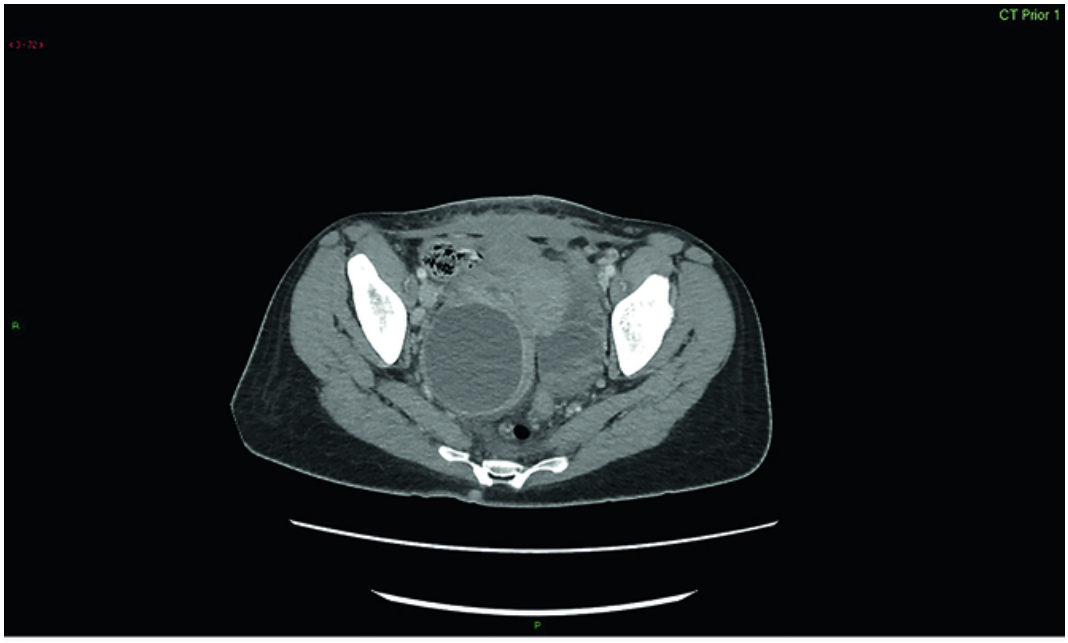
| |
|---|
| Ceftriaxone 1 g IV every 24 hours |
| ***PLUS*** |
| Doxycycline 100 mg orally or IV every 12 hours |
| ***PLUS*** |
| Metronidazole 500 mg IV every 12 hours |
| **OR** |
| Cefotetan 2 g IV every 12 hours |
| ***PLUS*** |
| Doxycycline 100 mg orally or IV every 12 hours |
| **OR** |
| Cefoxitin 2 g IV every 6 hours |
| ***PLUS*** |
| Doxycycline 100 mg orally or IV every 12 hours |
| **Alternative Parenteral Regimens**: |
| Ampicillin-sulbactam 3 g IV every 6 hours |
| ***PLUS*** |
| Doxycycline 100 mg orally or IV every 12 hours |
| **OR** |
| Clindamycin 900 mg IV every 8 hours |
| ***PLUS*** |
| Gentamicin loading dose IV or IM (2 mg/kg body weight), followed by a maintenance dose (1.5 mg/kg body weight) every 8 h; single daily dosing (3-5 mg/kg body weight) can be substituted |

Modified from Workowski KA, Bachmann LH, Chan PA, et al. Sexually transmitted infections treatment guidelines, 2021. *MMWR Recomm Rep*. 2021;70(No. RR-4):1-187.

There is insufficient evidence to suggest that women with HIV or patients with an IUD require more aggressive management of PID; the same antibiotic regimens and criteria for inpatient management may be used. The IUD does not need to be removed. If no clinical improvement occurs within 48-72 hours of initiating treatment, then IUD removal should be considered.

# PERCUTANEOUS DRAINAGE

Patients showing evidence of sepsis or with very large abscesses generally need urgent surgical treatment. Most other patients needing inpatient management should be treated for 48-72 hours with parenteral antibiotics before moving to drainage or surgery, ideally avoiding these interventions altogether if possible. Percutaneous CT-guided drainage has gained popularity as it may avoid the need for surgery in some patients (**FIG. 41.2**). Studies have reported 70%-100% treatment success with this approach. Retrospective studies demonstrate a potential benefit of CT-guided percutaneous drainage compared to antibiotics alone, but there are no quality clinical trials comparing the effectiveness of image-guided percutaneous drainage and surgery. Drainage avoids risks associated with general anesthesia and risks of surgery in general but may not be effective in certain cases such as multiloculated collections. Patients managed with drainage may take longer to resolve their infection, compared to patients undergoing extirpative surgery. Another option for drainage is to perform laparoscopic drainage. This should be considered if radiologists do not feel they can target the abscess due to the presence of obstructing bowel or other structures. Laparoscopic drainage can also be performed if laparoscopy is performed for diagnostic purposes and an unexpected abscess is encountered (**BOX 41.1**).

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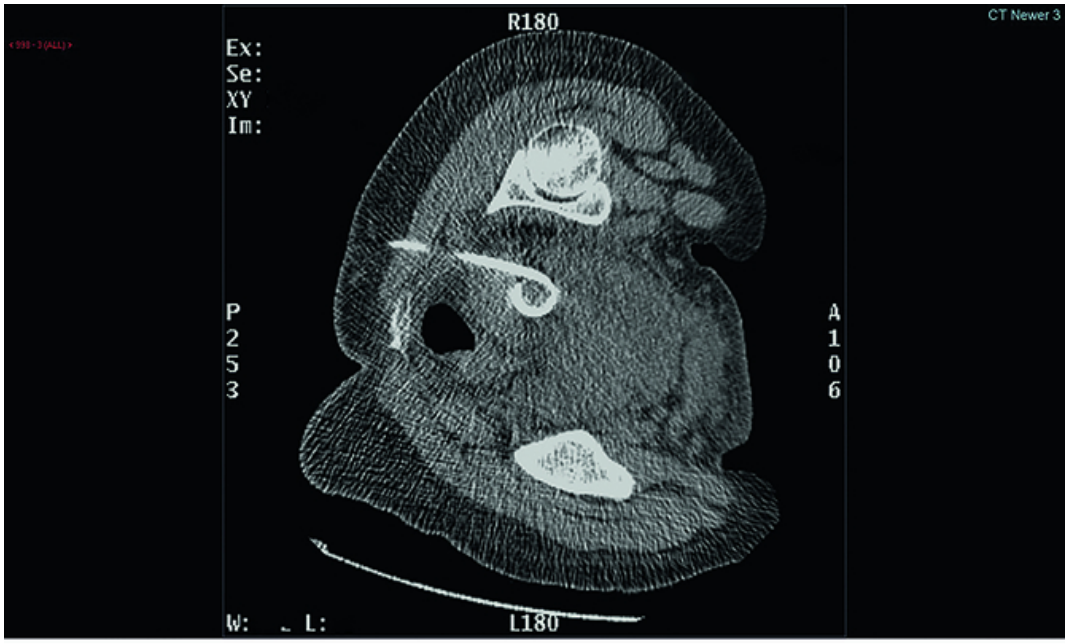


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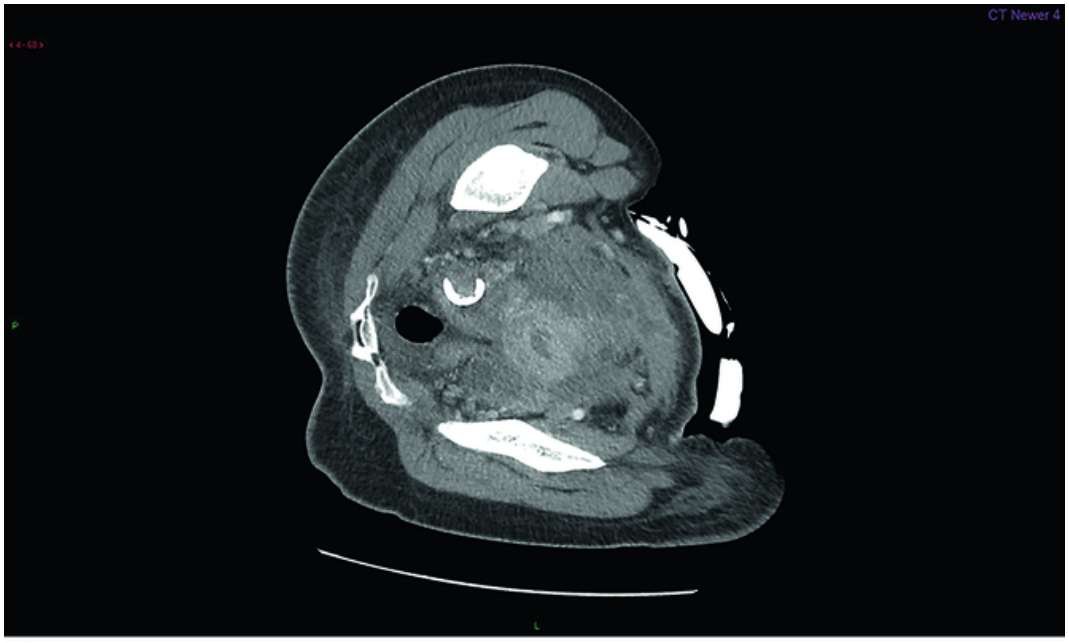


C

**FIGURE 41.2** CT-guided drainage of TOA. **A.** Large right-sided tuboovarian abscess. **B.** CT-guided insertion of pigtail catheter. **C.** Significant reduction in size of TOA, 3 days postprocedure. (Courtesy of H. Gabriel Lipshutz, MD; Cedars-Sinai Medical Center.)

## BOX 41.1 STEPS IN THE PROCEDURE

### Laparoscopic Drainage

- Establish laparoscopic access and pneumoperitoneum.
- Place auxiliary trocars.
- Examine entire pelvis, upper abdomen, and appendix.
- Obtain cultures from pelvic fluid and fimbriae of fallopian tubes.
- Use suction irrigator to aggressively break up and suction loculated exudate.

- Copiously irrigate with sterile saline or lactated Ringer's, instilling and suctioning several liters.
- Place closed-suction (eg, Jackson-Pratt, Blake, or similar) drain with the fenestrated end in dependent portion of the pelvis/posterior cul-de-sac and the end that connects to the bulb through a lower trocar incision.
- Attach the drain to a bulb with suction, and suture the drain in place to the skin.

Most patients with TOA who resolve their acute infection will eventually need surgical treatment. A delay of 2-3 months following antibiotic treatment is recommended to resolve inflammatory changes and make surgery less difficult. Patients who are not candidates for or do not improve with percutaneous drainage will need urgent surgery.

# SURGICAL TREATMENT

Diagnostic laparoscopy is recommended if surgical sources of pain are in question, for example, if endometriotic cyst rupture or appendicitis is suspected, previous testing is inconclusive, or the patient is not responding to presumptive treatment. Diagnostic laparoscopy is typically not indicated for mild symptoms. Surgical evaluation should include direct tissue sampling for culture as well as endometrial sampling to evaluate for endometritis. Laparotomy is not indicated for strictly diagnostic purposes, and referral to a specialist should be considered due to the well-documented advantages of minimally invasive surgery (MIS) over open surgery and the anticipated complexity of any subsequent operative intervention.

Laparoscopy is a low-risk intervention, and allows the surgeon to perform culture, irrigation, and surgical drainage. The minimally invasive approach facilitates effective treatment, faster response rates, shorter hospitalization, and improved fertility outcomes. Early surgical management is also associated with reduced blood loss and operative time, which may also decrease development of adhesion formation and reduce the severity of long-term sequelae.

Patients desiring future pregnancy are likely to benefit from early surgical intervention and prompt antibiotic therapy, especially in cases where a TOA is present. Laparoscopic drainage within 24 hours has been shown to more than triple the likelihood of future pregnancy by reducing tubal damage, pelvic adhesions, and the risk of developing recurrent TOA.

Given the increased risk of ovarian cancer in postmenopausal patients, the presence of a pelvic infection in this patient population may be an indication for upfront laparoscopy to arrive at an accurate diagnosis.

# Preoperative Planning

Preoperative planning should involve securing a sufficiently skilled surgical team. Acute infection is associated with tissue edema, friability, and distorted tissue planes (**FIG. 41.3**). In the setting of a large abscess, surgeons should be prepared for the dissection of extensive adhesions involving small and large bowel. It may be helpful to request assistance from a general surgeon as well. Commonly, an infected fallopian tube will be damaged beyond salvage in the setting of TOA, so fertility preservation would be directed at uterine and ovarian conservation. Possible ovarian or uterine resection should be discussed with patients prior to surgery during the consent process.

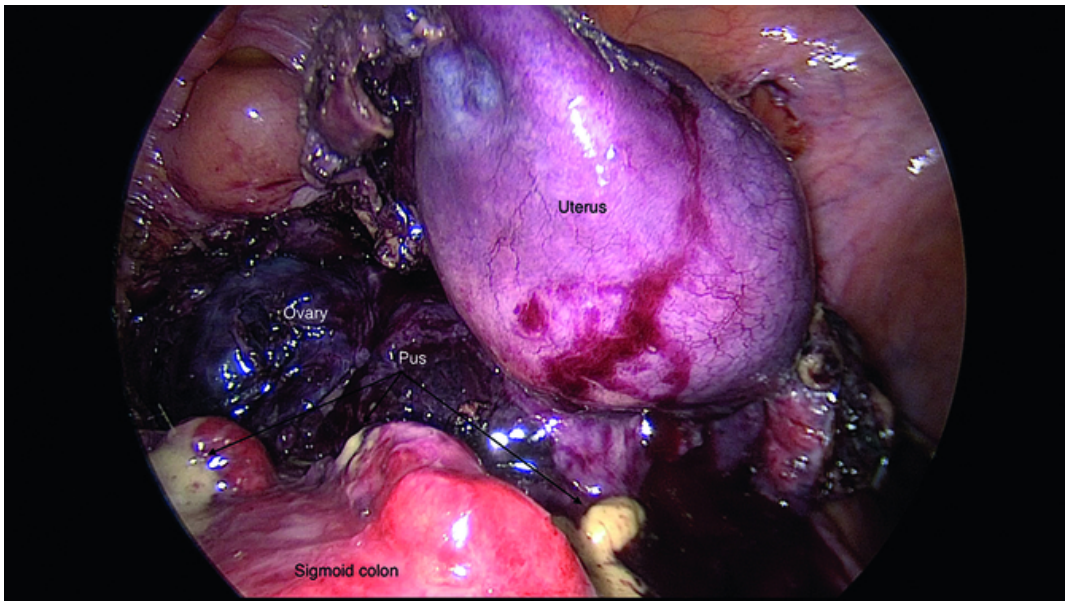


**FIGURE 41.3** Pelvic view of severe PID showing inflamed uterus and bilateral TOAs. The tissue planes are indistinct, friable, bloody, and edematous.

If operative laparoscopy is planned, it should be performed in coordination with a surgeon with extensive experience in MIS. Laparoscopic drainage alone is unlikely to be sufficient to result in significant clinical improvement. Patients with sepsis will require resection of affected tissue, adnexectomy at minimum, and possibly hysterectomy and removal of both tubes and ovaries depending on the severity of disease. Completing such a procedure laparoscopically is quite difficult due to the challenges in tissue planes and adequate exposure. These operations can be even more difficult than cancer surgery or resection of advanced endometriosis cases because the retroperitoneum is edematous and easily stained by blood and pus. Surgeons without extensive experience in laparoscopy should have a low threshold to convert to laparotomy and should consider proceeding directly to laparotomy given the complexity of these operations. A vertical midline incision is typically recommended for laparotomy to provide adequate exposure. A

transverse incision may be insufficient to provide visualization of the entire pelvis and lower abdomen.

# Intraoperative Management

Diagnosis of ruptured TOA is considered an indication for surgical intervention and source control because of the high risk for systemic complications and sepsis. Death due to adult respiratory distress syndrome (ARDS) may occur in 5%-10% of cases with ruptured TOA if treatment is delayed or inadequate.

Most often, surgical management of PID occurs in the setting of TOA that has failed antibiotic therapy, which happens in ~25% of patients with TOA. TOA diameter larger than 5-7 cm has been correlated with an increased risk of needing surgical intervention for disease resolution. Other patient factors such as age, fever, parity, increasing levels of serum inflammatory biomarkers (WBC count, ESR, CRP), presence of an IUD, and smoking are possible risk factors for antibiotic therapy failure, but studies of these factors are not conclusive. TOA morphology (unilocular vs complex) has not been shown to be correlated with failure of medical management. Given the lack of reliability of using clinical parameters to predict antibiotic failure, ultimately provider judgment and a combination of clinical factors should be used to determine the need and timing for surgical intervention.

Regardless of approach, the procedure should start with retroperitoneal dissection. As in any case with challenging adhesions, opening retroperitoneal spaces distant from the pathology and working one's way to the difficult areas will make surgery easier. Ureterolysis may be required. The easiest place to identify the ureter is its most superficial location—just as it crosses into the pelvis at the level of the bifurcation of the common iliac into the external and internal iliac arteries. It can then be followed along its pelvic course with blunt dissection using a "push and spread" technique while retracting the adnexa medially (**FIG. 41.4**).

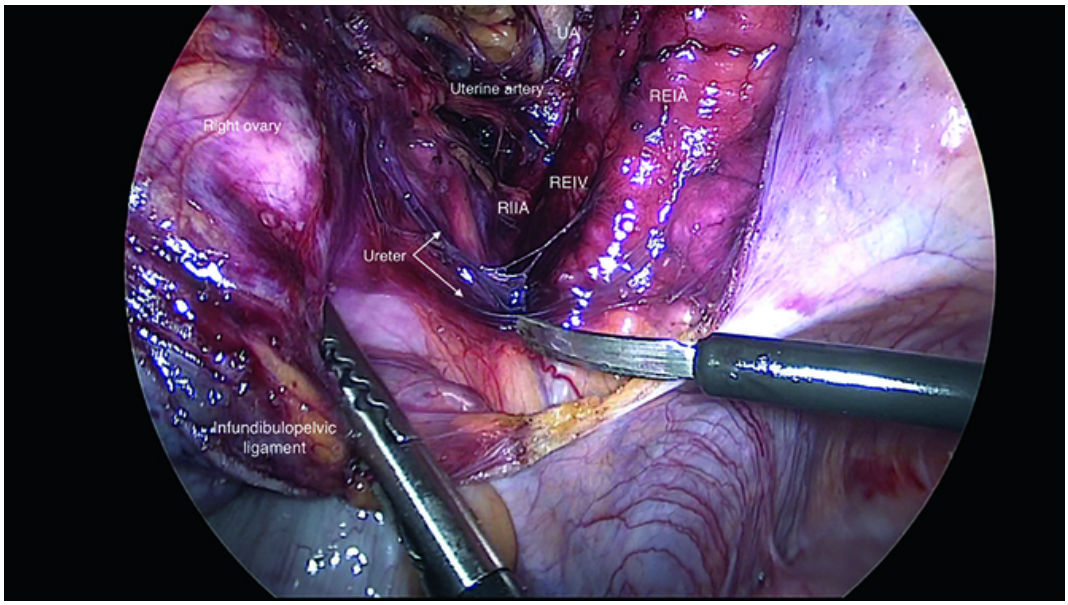


**FIGURE 41.4** The ureter can be dissected along its pelvic course with blunt dissection using a "push and spread" technique while retracting the adnexa medially. UA, umbilical artery; REIA, right external iliac artery; REIV, right external iliac vein; RIIA, right internal iliac artery.

If hysterectomy is intended, it is helpful to ligate the uterine artery at its origin as it branches off the internal iliac (hypogastric) artery (**FIG. 41.5**) as a large TOA can occupy a good portion of the pararectal and paravesical spaces. The origin of the uterine artery can be identified by dissecting and unroofing the ureter to where it crosses through the tunnel of Wertheim under the cardinal ligament and by dissecting the internal iliac directly to its terminal branches, or following the obliterated umbilical artery (medial umbilical ligament) along the anterior abdominal wall into the pelvis. The remainder of the avascular spaces of the pelvis relevant to hysterectomy should be generously developed, as with any difficult hysterectomy.

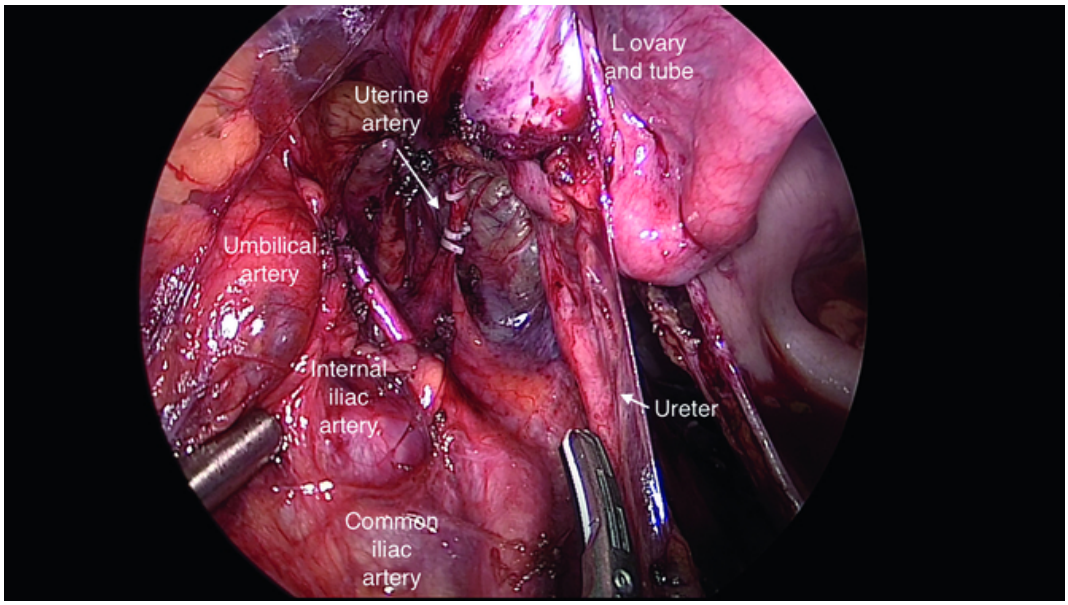


**FIGURE 41.5** Ligation of the uterine artery at its origin off the internal iliac artery. The origin of the uterine artery can be identified by dissecting the ureter to where it crosses through the tunnel of Wertheim under the cardinal ligament, by dissecting the internal iliac directly to its terminal branches, or by following the obliterated umbilical artery (medial umbilical ligament) along the anterior abdominal wall into the pelvis.

The pararectal and paravesical spaces will have already been opened to dissect the ureter and ligate the uterine artery at its origin as described previously. The vesicovaginal space should be generously developed, especially if total hysterectomy is being performed as this will facilitate cuff closure. Insufficient mobilization of the bladder may hinder removal of all of the infected tissue, impair cuff closure, or lead to inclusion of the bladder in cuff closure, which could lead to cuff breakdown and dehiscence, or vesicovaginal

fistula formation as a more severe complication. Completely opening the vesicovaginal space also allows for complete skeletonization of the uterine artery at the level of the cervix, where it will be divided. This step is always important because the ureter crosses 1-2 cm lateral to and under the uterine artery.

If oophorectomy is performed, the gonadal pedicle should be skeletonized and divided well away from the ovarian hilum. The retroperitoneum should be opened and infundibulopelvic (IP) ligament divided away from the ovary to avoid risk of ureteral injury or leaving an ovarian remnant. An incision is made lateral to the IP ligament and carried cephalad above the pelvic brim. The IP is retracted medially and isolated by creating a window in the posterior broad ligament (**FIG. 41.6**). The ureter is then identified in the pararectal space and the IP ligated and divided. If the uterus is being conserved, the fallopian tube and utero-ovarian ligament are divided. In normal cases, this would nearly free the adnexa, but significantly more adhesiolysis may be needed in cases of TOA to free the complex from the uterus, sidewall, bladder, small bowel, and/or sigmoid.

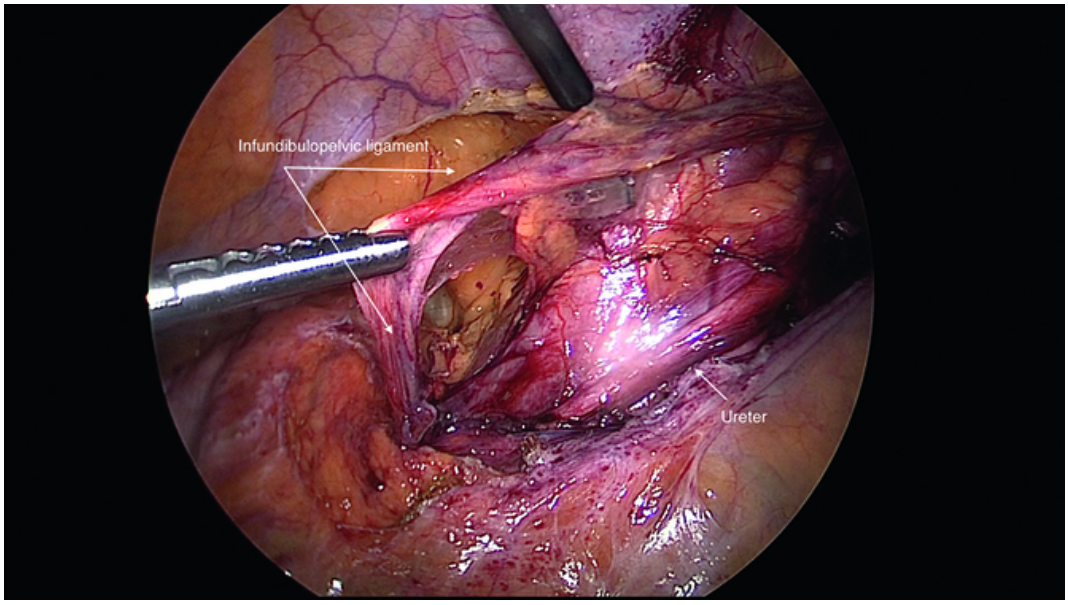


**FIGURE 41.6** The infundibulopelvic ligament (gonadal pedicle) is retracted and isolated by

creating a window in the posterior broad ligament.

If fertility preservation is the goal, one generally preserves the uterus and ovaries. A fallopian tube affected by ascending infection is unlikely to be functional, and surgical management includes salpingectomy in addition to drainage of an abscess. If an infection is mild enough to warrant salpingectomy alone, the procedure is relatively straightforward. Laparoscopically, an advanced bipolar device is used to divide the mesosalpinx from fimbriae to cornu or vice versa. If laparotomy is performed, Kelly clamps are placed across the mesosalpinx, and the tube is excised with electrosurgery or scissors. The resultant pedicles are then suture ligated with delayed absorbable ligatures.

Attention should be paid to the appendix when exploring patients with PID and TOA. Undoubtedly, some cases of adnexal infection are secondary to appendicitis due to its proximity to the right tube and ovary. Endometriosis may cause the appendix to become adherent to the right adnexa, and subsequent infection could then lead to TOA. If there is any suspicion of appendiceal inflammation during surgery for PID, an appendectomy is a simple procedure to add in most cases.

To perform appendectomy, isolate the appendiceal artery, a branch of the ileocolic and superior mesenteric arteries, and ligate the remainder of the mesoappendix using electrosurgery (**FIG. 41.7**). The base of the appendix is then ligated with surgical ties, a stapling device, or a pretied extracorporeal snare device (eg, Endoloop, Ethicon, Somerville, New Jersey).

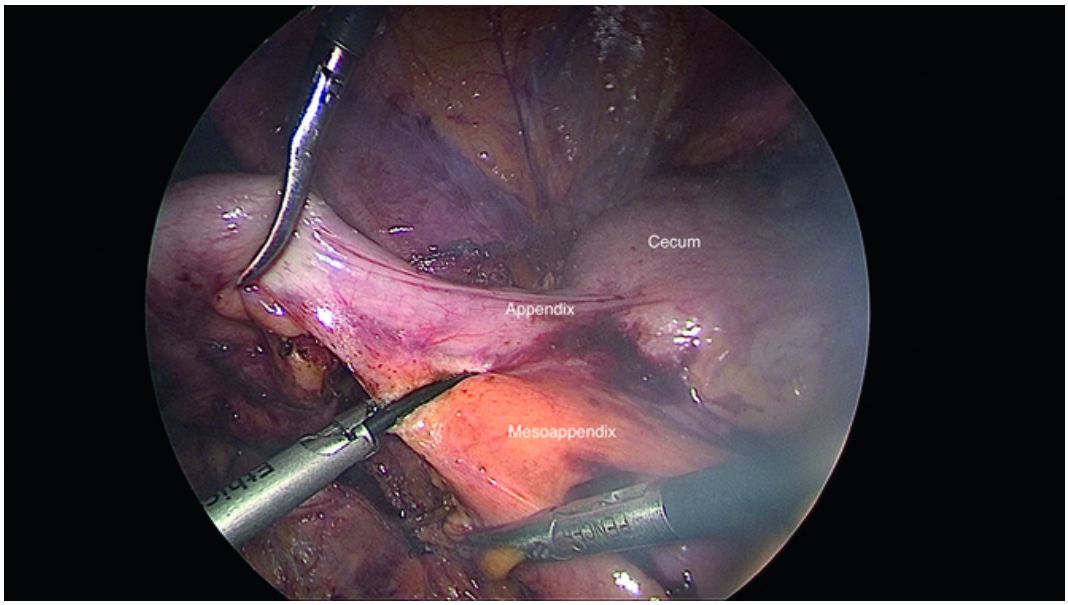


**FIGURE 41.7** The appendiceal artery is isolated and ligated, and the remainder of the mesoappendix is divided with electrosurgery.

Bowel adhesions should be carefully freed. The surgeon should be cautious to avoid undue traction on tissues as these will be inflamed and edematous. Small bowel is more delicate than large, and even with the most gentle of dissection, enterotomy or deserosalization may be unavoidable. If not expedient or feasible to repair immediately, the injured area can be tagged with a suture with a long tail so it can be readily identified and fully repaired later once the abscess and/or infected organs are removed. Minor areas of deserosalizations do not need repair. More significant deserosalizations or tears involving the muscularis should be repaired with interrupted stitches of fine-caliber delayed absorbable suture, such as 3-0 Vicryl (Ethicon, Somerville, New Jersey). Full-thickness enterotomies need double-layer closure, and segmental resection is indicated if more than a third of the circumference of the bowel is involved. Resection should also be considered in the setting of multiple deserosalizations or if there is a large section of devascularized small bowel. Large bowel is more forgiving, but the same basic principles apply. One should have a low threshold to call

a general or trauma surgeon to assist with difficult bowel situations. See Chapter 38 for detailed description of appendectomy procedure and repair of serosal bowel defects.

# DELAYED SURGICAL MANAGEMENT

Patients with mild PID, such as salpingitis, may have no sequelae following antibiotic treatment and avoid surgery altogether; however, hydrosalpinx is a common complication of ascending genital infection. These can be observed if the patient is asymptomatic, but hydrosalpinx and chronic salpingitis can cause pelvic pain and require salpingectomy in the future. Hydrosalpinges may also require removal to facilitate *in vitro* fertilization. In patients with resolving TOA, surgery should ideally be delayed 2-3 months following antibiotic treatment. Adhesions will still be present but will have remodeled to become less edematous and friable and allow tissue planes to be more easily developed. The likelihood of ovarian salvage is significantly improved if the acute infection has cleared prior to surgery.

# WOUND MANAGEMENT

After hysterectomy for PID, the colpotomy may be closed primarily with or without drain placement. A Jackson-Pratt or Blake drain may be placed to prevent the accumulation of blood or pus near the vaginal cuff, if bowel resection or urinary tract repair is performed, or if surveillance of pelvic fluid is desired. The need for an intraperitoneal drain is based on the extent and duration of infection as well as surgical factors. If used, the drain can exit transvaginally through the cuff or through a separate abdominal skin incision. Historically, the vaginal cuff has been left open for drainage in the setting of acute pelvic infection; there is no robust evidence that cuff closure by secondary intention is better than primary closure. For patients in whom laparotomy is performed, the skin may be closed primarily utilizing an en masse closure.

# POSTOPERATIVE CARE

Strong consideration should be given to placing PID patients in the intensive care unit or step-down unit postoperatively due to risks of septic shock, bacteremia, and fluid imbalances following PID surgery. Postsurgical PID patients are at increased risk for development of ileus, intestinal obstruction, surgical site infection and dehiscence, pulmonary embolus, and disseminated intravascular coagulation compared to routine postsurgical patients. In cases of severe sepsis, renal or respiratory compromise may further complicate recovery. Once patients demonstrate clinical stability, they may be transferred to a less acute inpatient setting.

Septic shock should be managed with crystalloid resuscitation, respiratory support, and vasoactive medications if necessary, in addition to broad-spectrum intravenous antibiotics until the patient can take antibiotics orally. Broad-spectrum antibiotics are recommended, and the regimen can be further refined when the results of the antibiotic sensitivity studies from intraoperatively collected cultures return. Antibiotics are discontinued when the patient demonstrates resolution of infection (afebrile, normal WBC count, meeting all postoperative goals). Transvaginal or percutaneous intraperitoneal drains are removed when there is clinical improvement and no further drain output and when imaging documents no remaining free fluid.

Patients are safely discharged home when they are stable and infection has resolved. After fertility-sparing procedures, a 14-day course of oral antibiotics is indicated and can be completed as an outpatient.

# KEY POINTS

- Pelvic inflammatory disease (PID) includes cervicitis, endometritis, salpingitis, tuboovarian abscess (TOA), and peritonitis, which develops from ascending genital tract infection.

- Bacterial PID infections are polymicrobial and arise from sexually transmitted pathogens as well as normal vaginal flora and require broad-spectrum antibiotic treatment.
- First-line treatment of PID includes a third-generation cephalosporin, plus doxycycline, and metronidazole.
- Treatment of PID should include antibiotics effective against *N gonorrhoeae* and *C trachomatis* even if nucleic acid amplification testing is negative.
- The same antibiotic regimens and criteria for inpatient management are recommended for patients with HIV and those with an IUD in place. An IUD does not need to be routinely removed to treat PID.
- Inpatient treatment is recommended based on provider judgment and if the patient fits any of the following clinical scenarios: surgical emergency cannot be excluded, presence of TOA, pregnancy, severe illness including nausea and vomiting or high fever, inability to follow or tolerate an outpatient oral regimen, or lack of a clinical response to oral therapy.
- Surgical intervention is indicated when the diagnosis is unclear, for TOA management when percutaneous drainage is not available or feasible, when the patient decompensates despite adequate initial treatment, or if there is no clinical improvement after treatment with 48-72 of parenteral antibiotics.
- Unilateral salpingectomy is usually performed when surgery is planned for management of PID (salpingitis or TOA) and is preferred in stable patients desiring fertility preservation.
- Extirpative surgery including hysterectomy and bilateral adnexectomy may be required to manage severe cases of TOA.
- Ideally, surgery for sequelae of PID, if necessary, should be delayed 2-3 months following successful outpatient treatment.

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# CHAPTER 42

# SURGICAL MANAGEMENT OF REPRODUCTIVE TRACT ANOMALIES

Jennifer E. Dietrich

**Surgical Management of Reproductive Outflow Tract Anomalies**

Class I Anomalies

Class II Anomalies

Class III Anomalies

**Surgery for Nonobstructive Anomalies**

Class I Anomalies

Class II Anomalies

Class III Anomalies

Class IV Anomalies

Class V Anomalies

Class VI Anomalies

**Management of Other Outflow Tract Anomalies**

**Other Associated Disorders**

**Summary**

Before 6 weeks gestational age, a common müllerian and wolffian system exists. From 6 to 7 weeks, differentiation occurs, allowing for müllerian persistence and development or suppression of development. As a result of müllerian development, the uterus, fallopian tubes, and upper vagina develop. Around 9 weeks gestational age, the urogenital sinus develops; this becomes a sinovaginal bulb at 15 weeks gestational age. This eventually fuses with the vaginal cord to form a vaginal plate and subsequently undergoes canalization at 20-26 weeks gestational age. Approximately 7% of young women and girls present with a reproductive tract anomaly.

There are several categories of anomalies as defined by Buttram and Gibbons: those with müllerian anomalies without an obstructive component and those associated with an obstructive müllerian outflow tract anomaly requiring surgical intervention. Nonobstructive anomalies are not associated with abnormalities of the external genitalia, and ovarian function is not affected. The time of presentation varies from the early adolescent years to adulthood. Nonobstructive conditions present in adolescence and as delayed puberty; however, these nonobstructive anomalies more often present in adult women as an incidental finding during a surgical procedure or during the course of an infertility workup. These patients are asymptomatic and infrequently present with pain. Obstructive conditions will present early in reproductive life, around the time of menarche or just following menarche. These patients present with pain and obstruction of müllerian outflow manifesting as menstrual abnormality. The management of reproductive tract anomalies is complex and requires that the physician have a full understanding of anatomy, as well as skill and comfort with managing such conditions due to the high risk of complications (**VIDEO 42.1**). Magnetic resonance imaging (MRI) is the gold standard for imaging and confirmation of anatomy, although 3-D ultrasound can demonstrate similar sensitivity for anatomic confirmation (**FIG. 42.1**).

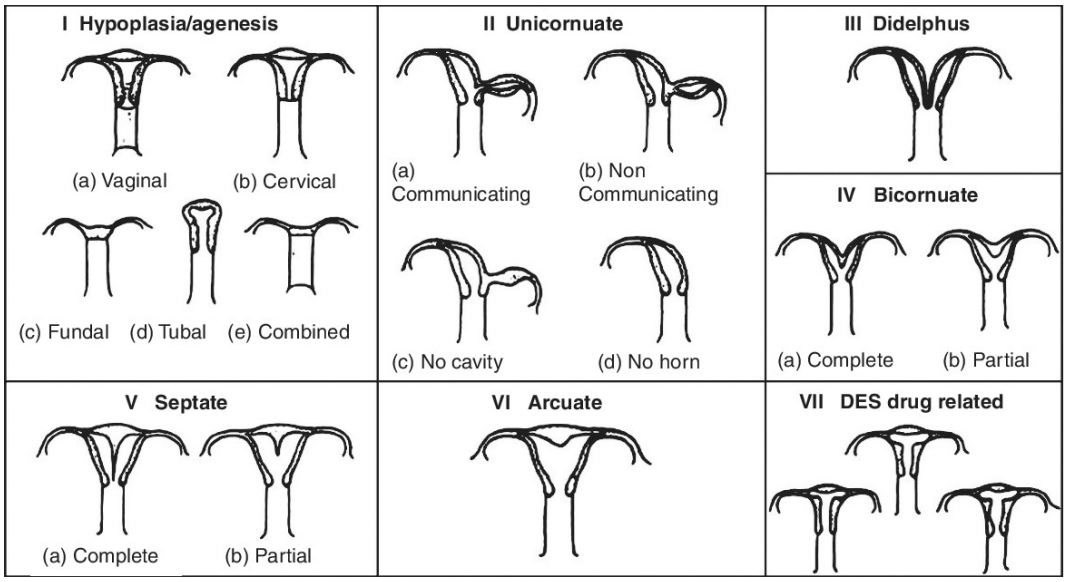



**FIGURE 42.1** American Fertility Society Müllerian anomaly classification. Nonobstructive anomalies are shown by class. (Reprinted from Buttram VC Jr, Gibbons WE. Müllerian anomalies: a proposed classification (an analysis of 144 cases). *Fertil Steril*. 1979;32(1):40-46. Copyright © 1979 American Society for Reproductive Medicine. With permission.)

# SURGICAL MANAGEMENT OF REPRODUCTIVE OUTFLOW TRACT ANOMALIES

It is helpful to understand the anomalies as allocated to their class. This class system was created by the American Fertility Society in order to better communicate the type of anomaly. Both obstructive and nonobstructive classes were determined based on the type of

anomaly involving lateral or vertical fusion defects, resorption defects, and agenesis or atresia.

# Class I Anomalies

Class I anomalies include complete to partial agenesis and dysgenesis of the uterus, vagina, cervix, or all of these structures.

## *Cervicovaginal Atresia*

Cervicovaginal atresia is a rare anomaly, which manifests as absent vaginal development, in addition to partial or complete absence of cervical development (**FIG. 42.2**). Young patients will present with pain following menarche due to a small uterine cavity that will fill and distend within 1-2 menstrual cycles. On genital examination, patients have no bulge effect but simply a vaginal dimple. This is a particularly hard diagnosis to establish, so it is important to utilize pelvic MRI to aid in the diagnosis. A hematometra should be evident on the MRI (**FIG. 42.3**). However, occasionally, the most distal aspect of the lower uterine segment can falsely appear as a small upper vagina or a premature truncation of the cervix or lower uterine segment. This differentiation is critically important because the surgical management is very different when cervical tissue is present. The cervix has important immune properties and musculature that simply cannot be recreated. If the diagnosis still cannot be established, there are a few options to discuss with the patient and family. Options include allowing more menstrual cycles to occur to further distend the small-volume obstructed space. Sometimes, this approach can identify the level where the agenesis or dysgenesis starts either at the vagina, cervix, or uterus. Another option for patients who are not ready to undergo surgical intervention is menstrual suppression with combined hormones, progesterone injections, or GnRH agonists.

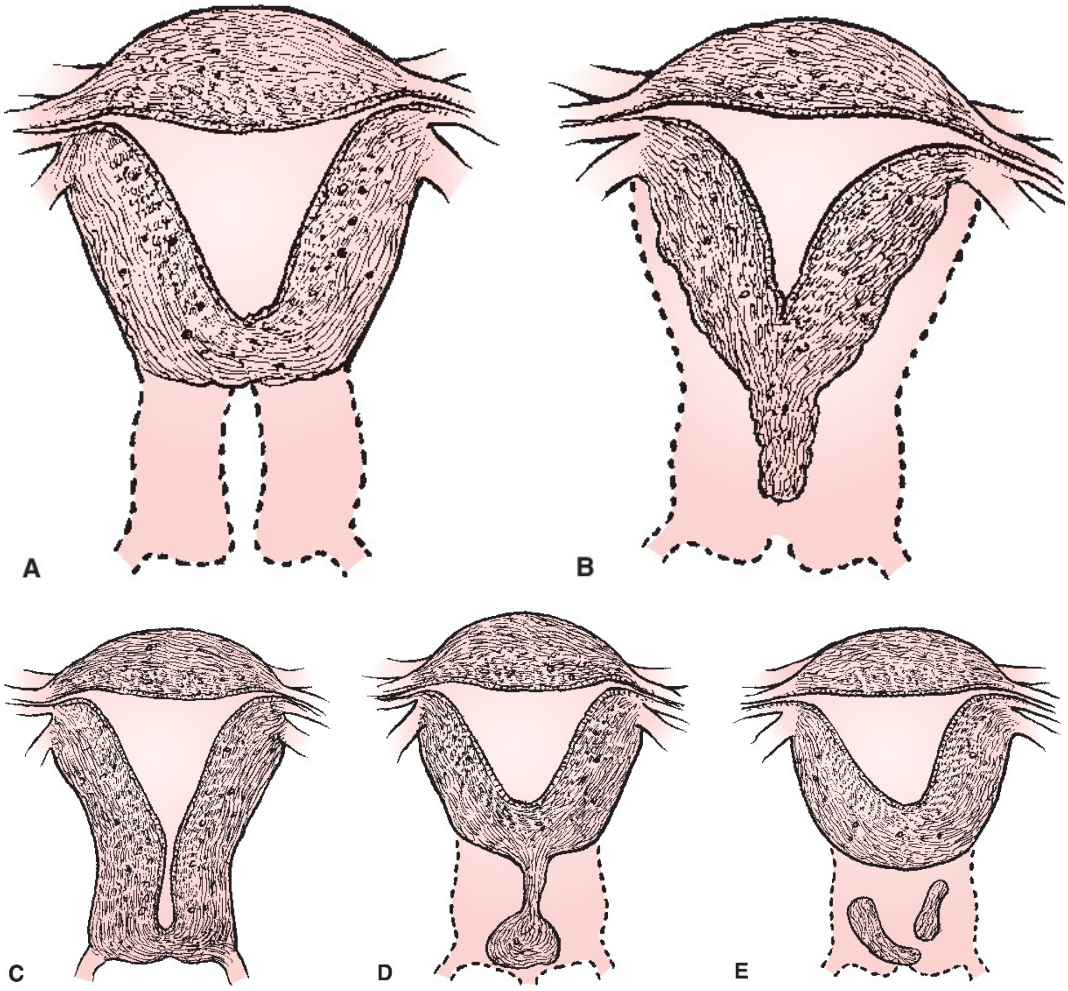



**FIGURE 42.2** Variation in congenital cervicovaginal atresia. **A.** The fundus of the uterus is noted without a cervix. **B.** The cervical body consists of a fibrous band of variable length and diameter that can contain endocervical glands. **C.** The cervical body is intact with obstruction of the cervical os. Variable portions of the cervical lumen are obliterated. **D.** Stricture of the midportion of the cervix, which is hypoplastic with a bulbous tip. No cervical lumen is identified. **E.** Cervical

fragments are present where portions of the cervix are noted with no connection to the uterine body. Hypoplasia of the uterine cavity can be associated with cervical cord fragmentation.

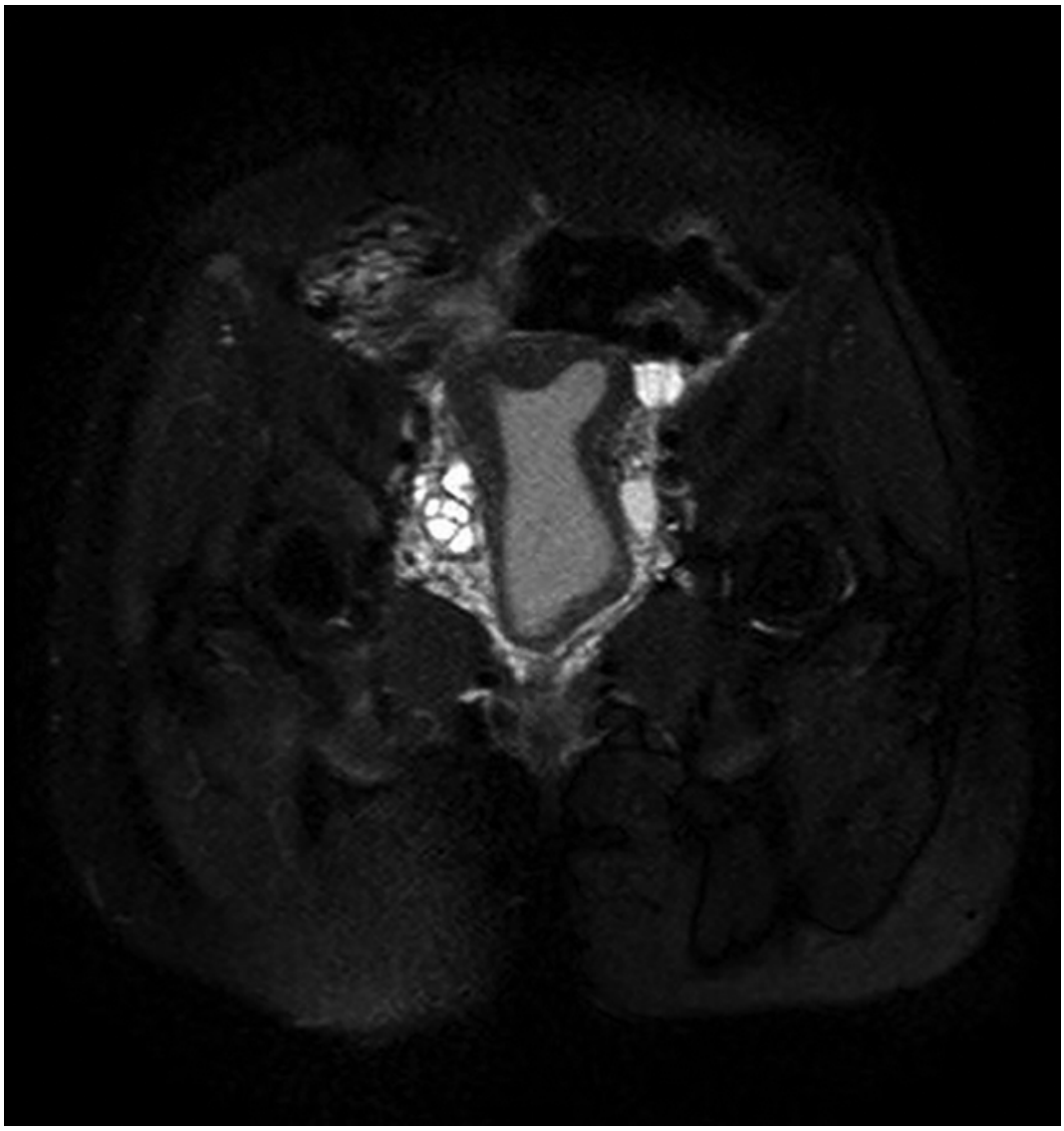


**FIGURE 42.3** MRI of cervicovaginal atresia showing a distorted remnant uterus with

hematometra.

If MRI cannot distinguish between cervicovaginal atresia and lower vaginal atresia, one can consider diagnostic laparoscopy, followed by reverse hysteroscopy. This involves making an incision with a cautery device at the uterine fundus, removing the menstrual contents, and viewing the uterus internally. A grasper can be used to remove tissue at the most distal aspect to determine if cervical tissue is present or absent.

Ideally, surgery should be performed to anastomose the uterus and the vagina. However, studies demonstrate high morbidity and mortality with this approach. Because of the inability to safely reconnect a uterus to the vagina, patients who are ready for surgery or no longer wish to continue menstrual suppression therapy can be offered uterine remnant removal. When planning to remove the uterine remnant, it is important to determine the proximity of the ureters to the level of uterine or cervical truncation as the anatomy is frequently distorted and the ureters may be close to the area of atresia. Depending on the patient's surgical history, removal of the midline uterine remnant can be accomplished via laparotomy or laparoscopy, although it can be easily approached laparoscopically in many cases. It is helpful to place ureteral stents prior to removal for improved visualization or tactile sensation during the dissection of the most distal part of the remnant at the level of the obstruction. Once the uterine remnant has been excised, it can be removed by laparotomy or placed within an endoscopic catch bag and morcellated through an umbilical entry site laparoscopically. Additional case reports in the literature have described the use of intestinal and skin grafts or porcine grafts for cervical reconstruction. Long-term outcomes are not yet available to assess the safety of these approaches (**BOX 42.1**).

## BOX 42.1 STEPS IN THE PROCEDURE

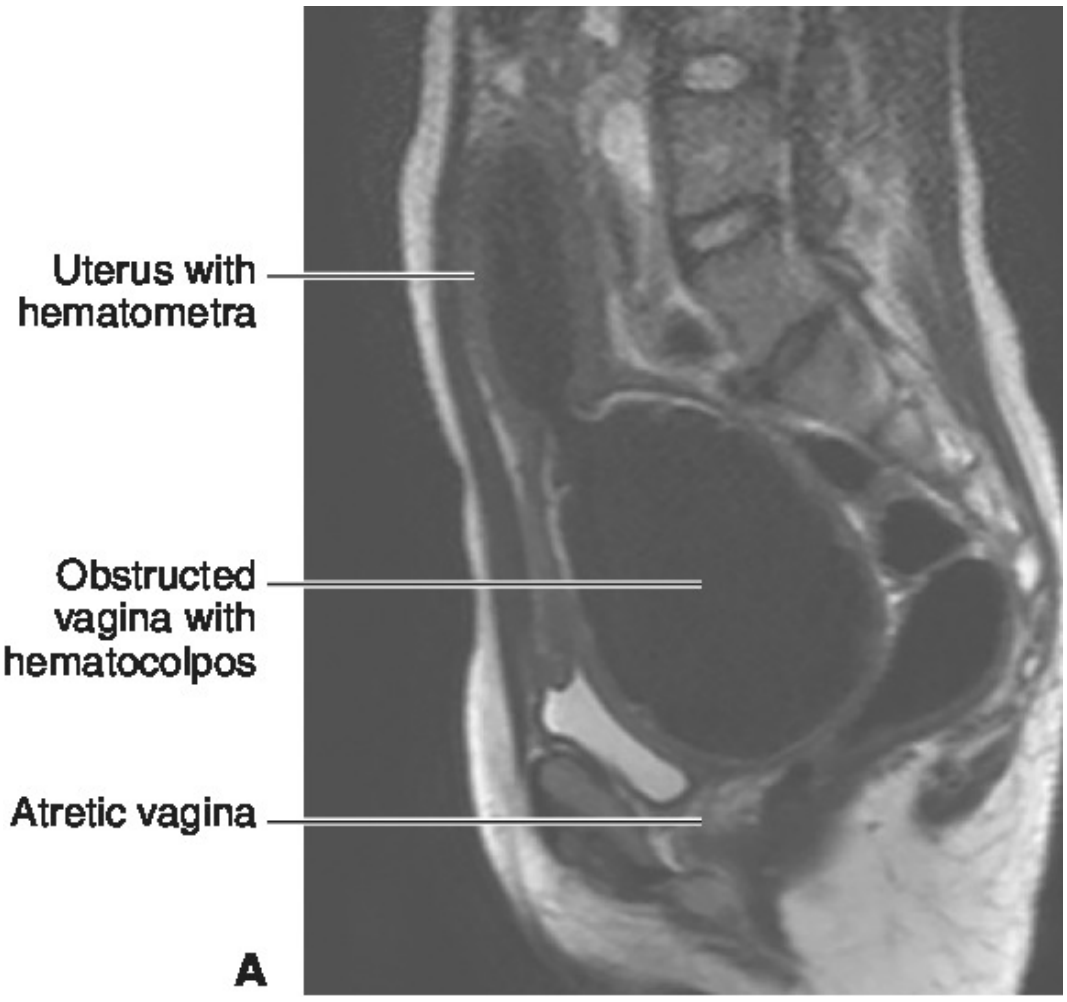
## Removal of Uterine Remnant Laparoscopically in Cervicovaginal Atresia

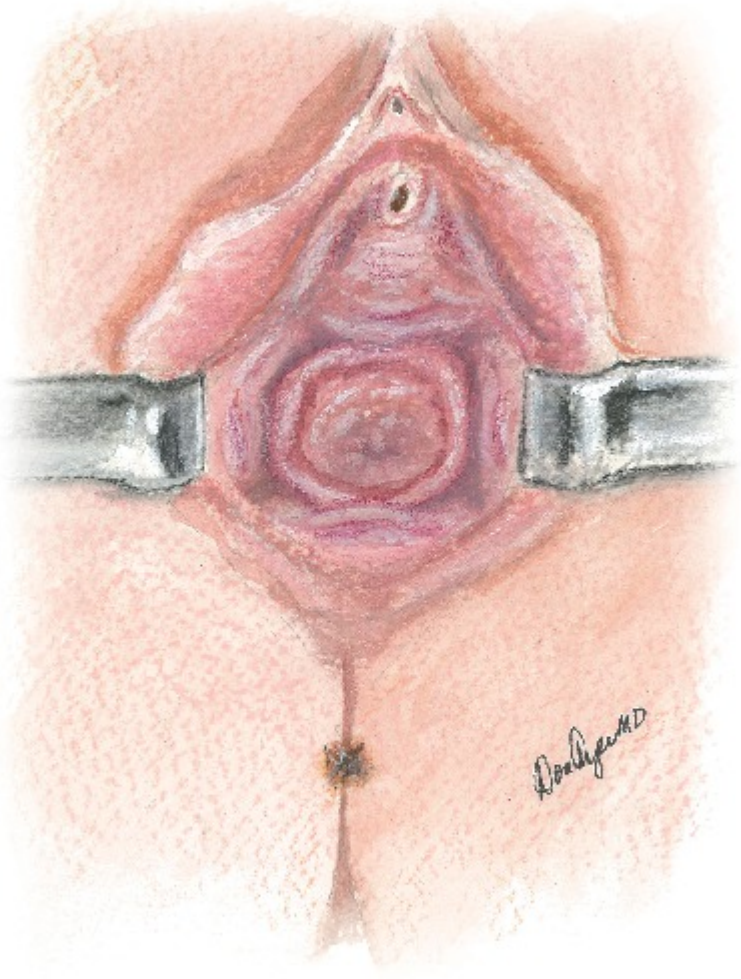
### Uterine Remnant Excision

- Catheterize the urethra to decrease the risk of injury.
- Place ureteral stents to identify ureters.
- Introduce laparoscope.
- Identify uterine remnant and begin removal with ligation and transection of the utero-ovarian ligament, cardinal ligament, and fallopian tube to allow adnexal structure to remain lateral.
- Create bladder flap.
- Continue ligation and transection of remnant uterine vessels until the area of atresia is reached and fully removed from the pelvis.

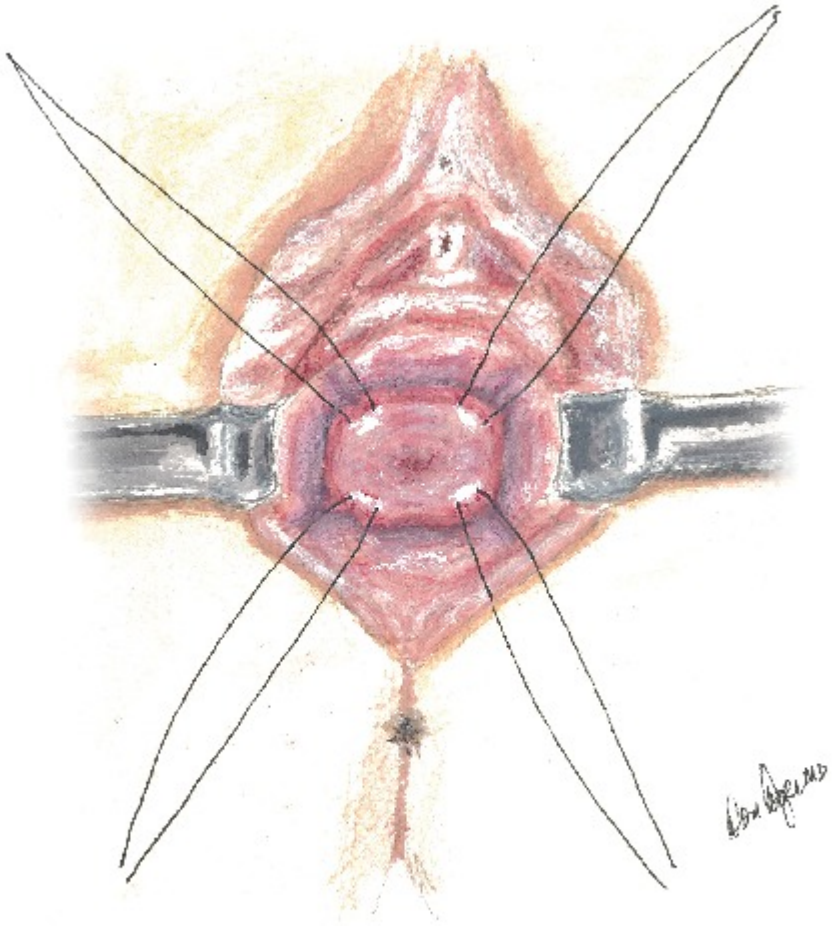
## *Lower Vaginal Atresia*

Class I anomalies also include lower vaginal atresia (**FIG. 42.4A**). This anomaly occurs when the müllerian portion of the vagina fails to properly canalize with the urogenital sinus or the urogenital sinus portion of the vagina. Patients will present with pelvic pain at puberty and amenorrhea. These patients will have a vaginal dimple on examination as well, occasionally with some bulging; however, the typical “blue hue” appearance seen with an imperforate hymen is not characteristic of this anomaly (**FIG. 42.4B**). A rectal examination can be helpful to determine the level of obstruction. In addition, it is important to obtain a pelvic MRI in order to assess the upper reproductive tract and to determine the distance between the hematocolpos and the perineum.

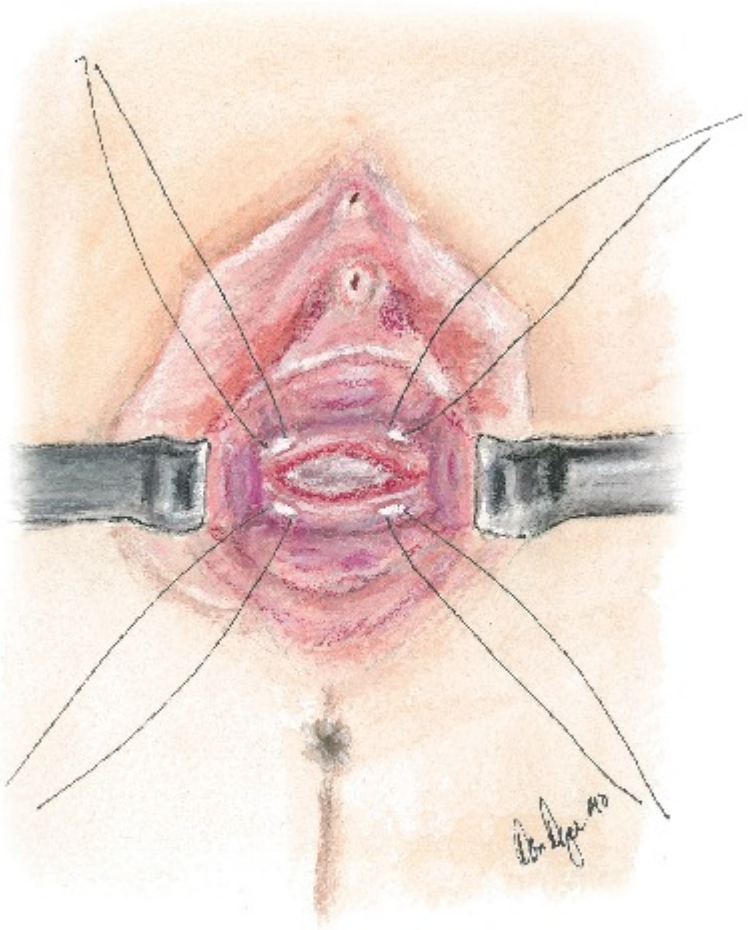

Uterus with hematometra
Obstructed vagina with hematocolpos
Atretic vagina
A



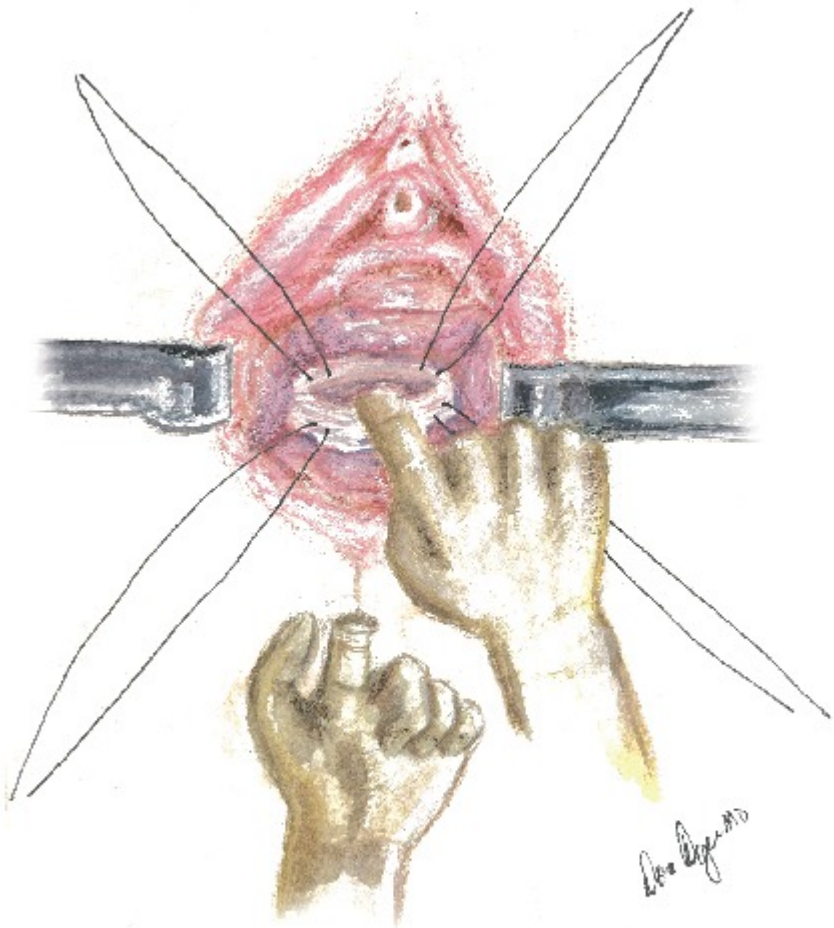
**B** Vaginal dimple



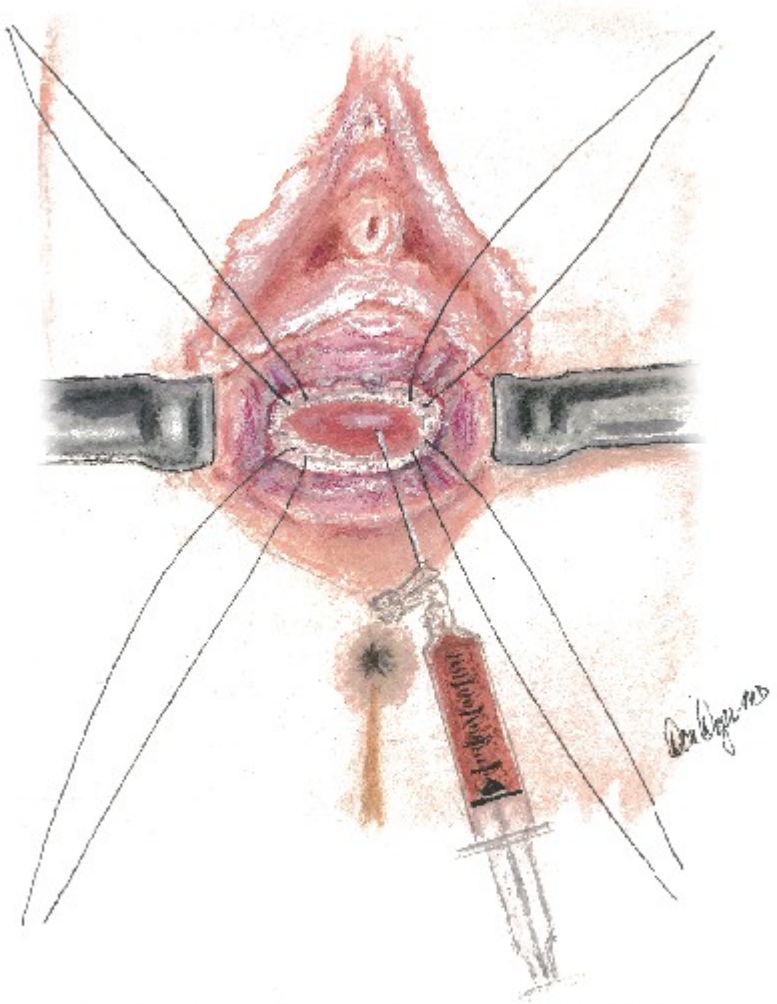
**C** Traction sutures place
**in 4 quadrants**



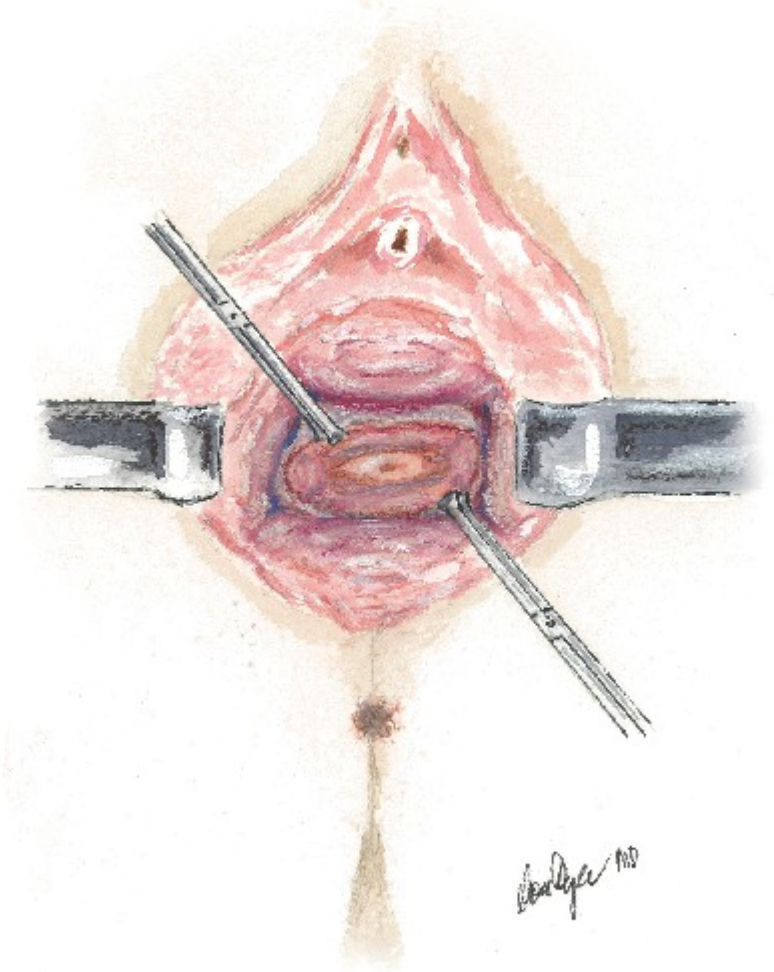
**D** Fibrous tissue of atretic vaginal space exposed after making lateral incision between sutures



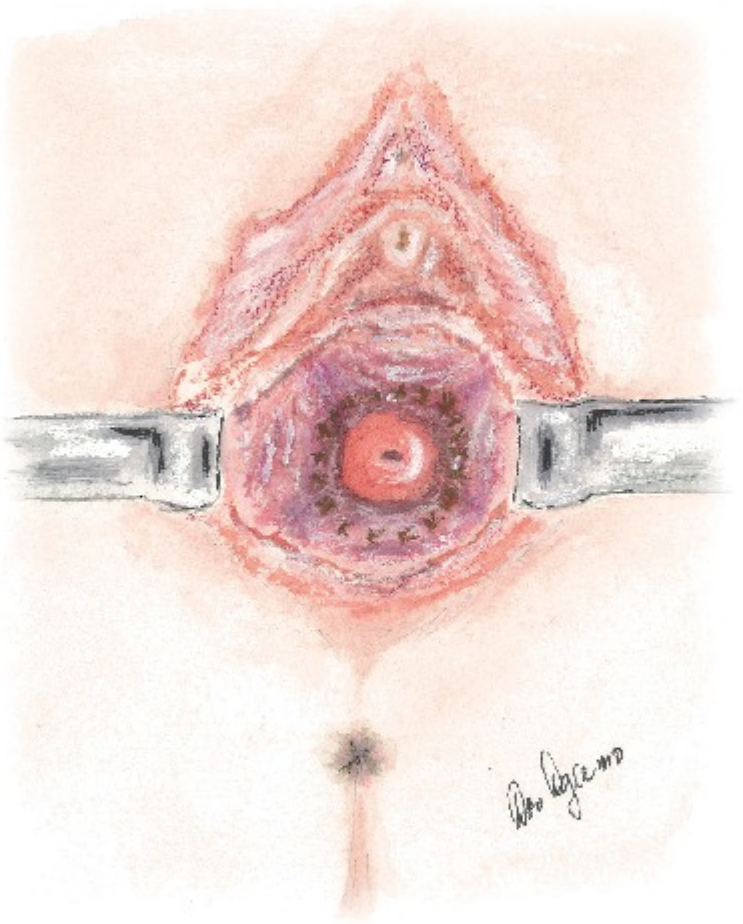
**E** Blunt dissection of fibrous space until bulging atretic vagina exposed



**F** Needle mapping the atretic vaginal bulge confirms the location of the space

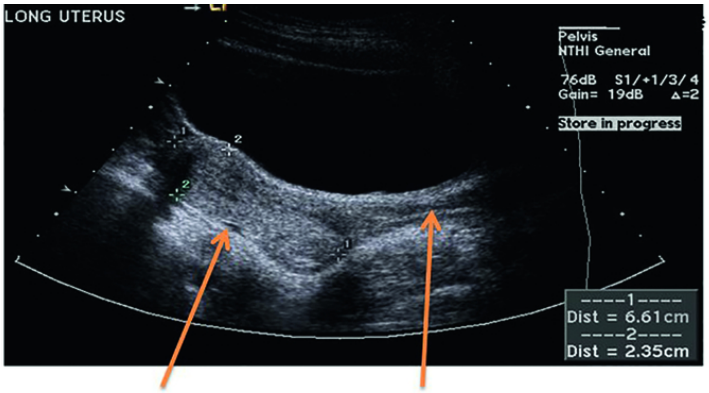


**G** The vagina is opened and **mucosal edges grasped**



**H** The vaginal mucosa from the **atretic vagina is then pulled to the perineum and sutured**

Ultrasound Post Vaginal Pull Through




Normal uterus non-distended

Normal vagina non-distended

I

**FIGURE 42.4** **A.** Sagittal MRI view of lower vaginal atresia. **B.** Vaginal dimple. **C.** Traction sutures place in four quadrants. **D.** Fibrous tissue of atretic vaginal space exposed after making lateral incision between sutures. **E.** Blunt dissection of fibrous space until bulging atretic vagina is exposed. **F.** Needle mapping the atretic vaginal bulge confirms the location of the space. **G.** The vagina is opened and mucosal edges are grasped. **H.** The vaginal mucosa from the atretic vagina is then pulled to the perineum and sutured. (Redrawn illustrations courtesy of Dr. Donald Dyer.) **I.** Pelvic ultrasound showing uterus and vagina without hematometrocolpos postvaginal pull-through procedure.

When the distance of the atretic vagina is ≤3 cm from the perineum, a straightforward vaginal pull-through procedure may be performed (**FIG. 42.4C-H**). When the distance is more than 3 cm, the risk of developing postoperative vaginal stricture is higher. It is then necessary to modify the approach. A pull through can still be attempted; however, if the lower atretic vagina does not descend into the pelvis toward the perineum, use of a graft is necessary. It is, therefore, important to discuss the option of preoperative vaginal dilation to stretch the dimple to bridge the distance if necessary. An alternative is to use graft tissue although it is better to use native vagina when possible. Surgery includes dissection to reach the bulging vagina behind the fibrous space and anastomosis of the stretched vaginal tissue to bridge the distance from the perineum to the atretic obstructed vagina. Potential complications include bowel

and bladder injury. It is important to have a clear understanding of the anatomy and know the distance from the perineum to the bulge. Mapping the space can be the most challenging, and a variety of approaches can be considered. A rectal examination is helpful to assess the location of the bulge. When the distance is still unclear, it may be helpful to have access to an ultrasound in the operating room. This is particularly useful when the distance between the atretic vagina and perineum is >3 cm.

When performing a pull-through procedure, a Foley catheter should be placed in the urethra to identify this structure and ensure that it is well away from the field of dissection. Traction sutures should be placed in four quadrants of the vaginal dimple followed by insertion of a spinal needle in the center. The identification of chocolate-colored fluid when the syringe is plunged back from the needle confirms the correct space. A scalpel is used to cut down on the needle in lateral directions. Once the space is wide enough for a suction, an Allis clamp is placed on the vaginal mucosal tissue and the suction tip is placed into the vaginal cavity to clear the hematocolpos. The atretic narrowed portion of the vagina is removed, and the normal-appearing wider-caliber vagina is then brought to the perineum and sutured with interrupted absorbable sutures circumferentially (**BOX 42.2**). After healing occurs from the pull through, pelvic ultrasound should demonstrate resolution of hematocolpos with a normal appearing vagina (**Fig. 42.4I**).

## BOX 42.2 STEPS IN THE PROCEDURE

### Vaginoplasty for Lower Vaginal Atresia

### Vaginal Pull Through ≤3 cm

- Catheterize the urethra to decrease the risk of injury.
- Place traction sutures on the vaginal dimple.
- For distances ≤3 cm from the perineum, insert a spinal needle in the center of traction sutures and withdraw to confirm the presence of hematocolpos fluid.

- Cut down on the spinal needle in lateral directions to expose the vaginal mucosa edges.
- Remove the narrow atretic portion with cautery device.
- Using Allis clamps on the vaginal mucosa, pull the mucosa to the perineum.
- Suture with absorbable suture (Vicryl) circumferentially in an interrupted fashion.

## *Uterovaginal Atresia*

Mayer-Rokitansky-Küster-Hauser (MRKH) syndrome occurs in 1/5000 girls and will typically present with amenorrhea without pelvic pain. These women have a 46XX karyotype, vaginal agenesis, and uterine agenesis.

Approximately 7%-10% of patients with MRKH will have functional uterine horn remnants, which are often displaced laterally (**FIG. 42.5**). At the time of laparoscopy performed to remove a functional remnant, it is common to see a midline band or cord of tissue between the bladder and rectum in the region of the missing uterus (**FIG. 42.6**). Once the diagnosis of MRKH has been established, a careful history regarding cyclic pelvic pain can be obtained. In the situation of recurrent episodes of pelvic pain, it is helpful to obtain a pelvic MRI to determine if uterine remnants can be visualized. It is not always possible to visualize these small remnants in their laterally displaced position. Regardless, if the history is notable for persistent cyclic pelvic pain, either menstrual suppression can be offered as an initial step or a diagnostic laparoscopy with surgical excision of the remnants can be undertaken. The remnants may be located within the pelvis below the pelvic brim or above the pelvic brim in some cases. Care must be taken to visualize the ureters during excision of the remnants with a vessel-sealing device. A recent survey of women with MRKH regarding uterine transplantation was performed. In this survey, 2/3 of women indicated that they would be interested in undergoing such a procedure for the opportunity to conceive. This procedure is still considered experimental and outcomes for delivering a baby range

up to 80% for those with graft survival of >6 months. However, there remain significant operative risks to the donor and recipient and postoperative complications include fistula formation and graft rejection.

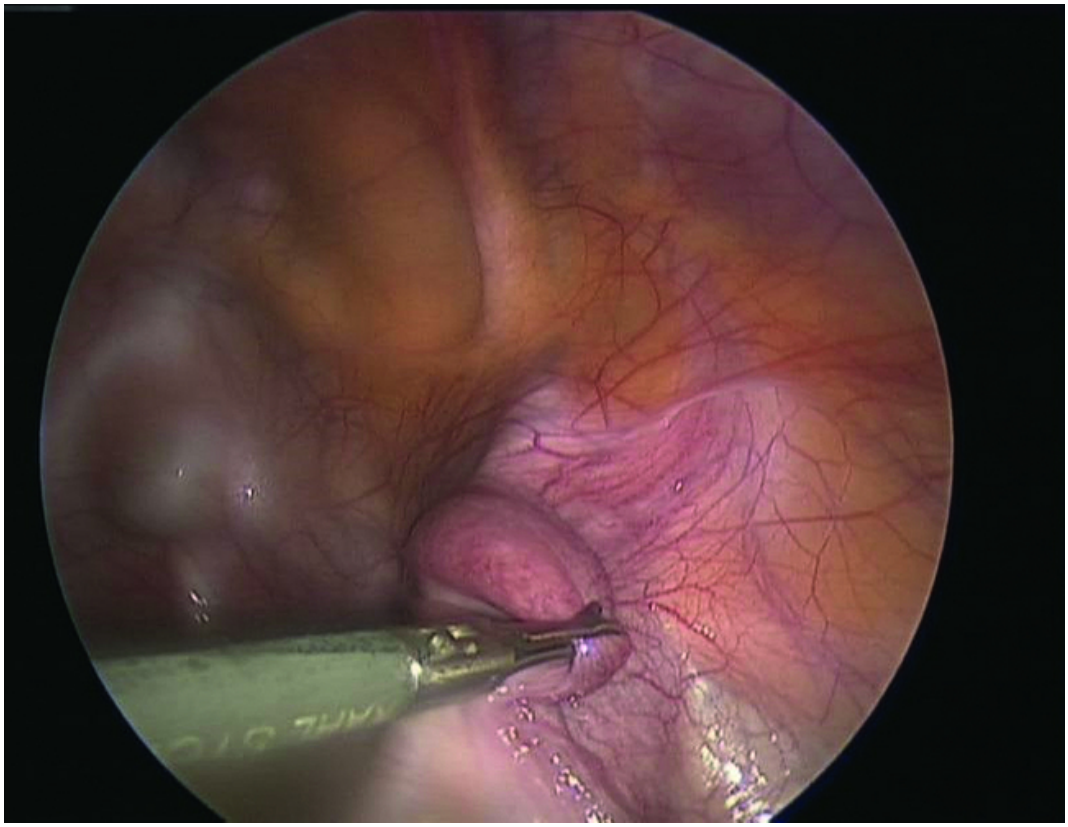


**FIGURE 42.5** Case of MRKH with uterine remnant visualized laparoscopically. The remnant is held by the grasper.

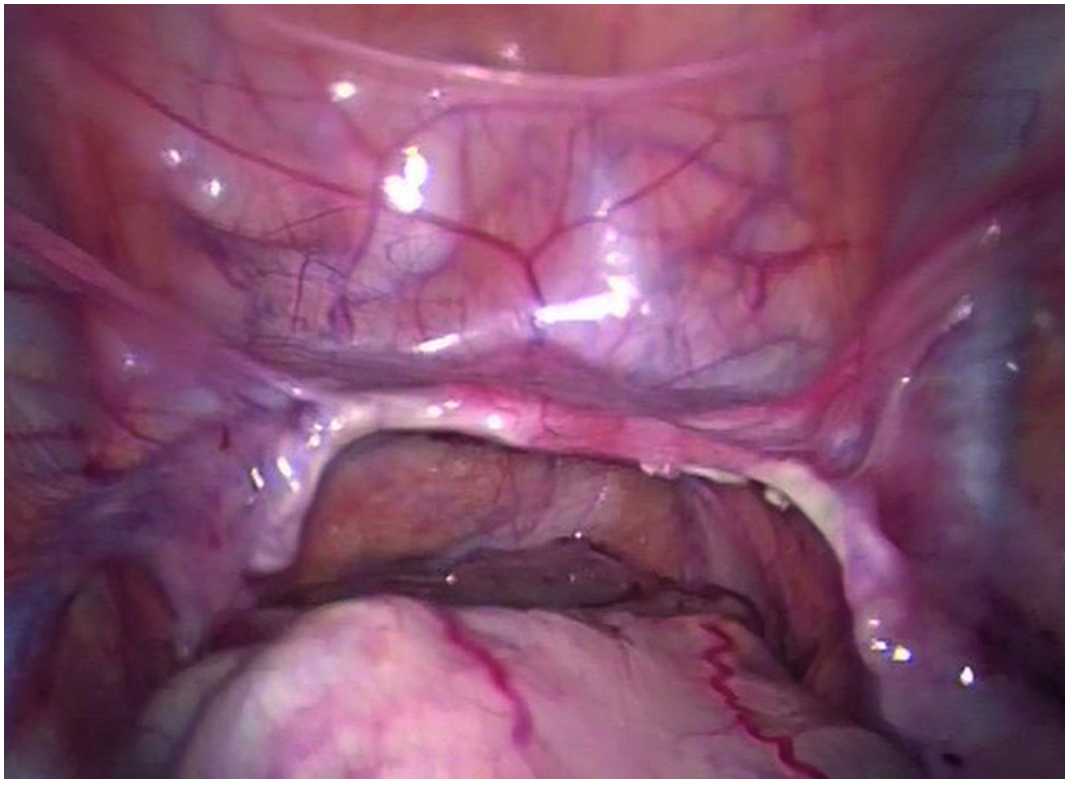


**FIGURE 42.6** Midline atretic cord or band in MRKH.

## Class II Anomalies

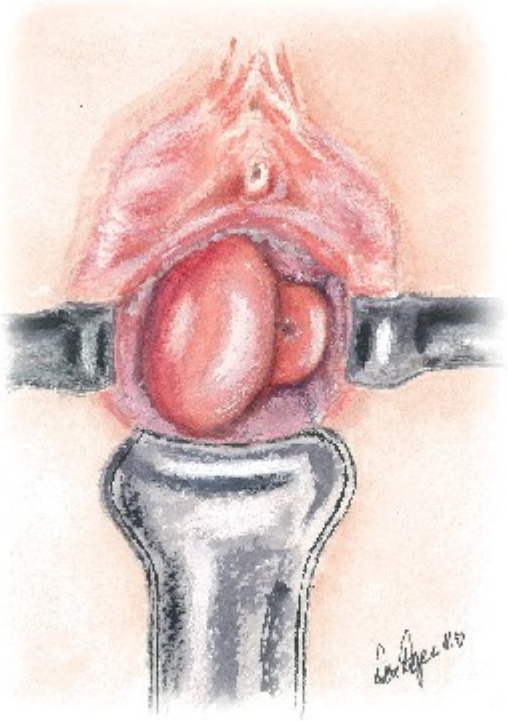
Class II anomalies include the unicornuate uterus, which occurs in 1 in 5400 young women. Up to 90% of cases are associated with a rudimentary uterine horn, and 25% of these cases will be associated with a functional noncommunicating uterine horn. This anomaly is partially obstructive in that the history reveals normal menses but progressively worsening episodes of pelvic pain over time. Complications associated with a functional communicating horn include ectopic pregnancy and rupture of the remnant horn. Ultrasound may not be able to distinguish an obstructed uterine remnant from a hemorrhagic cyst or uterine fibroid in some cases; therefore, it is important to confirm the diagnosis with pelvic MRI. For patients ready to pursue surgery, removal can be accomplished laparoscopically. If there is a need to distinguish between a

noncommunicating and communicating functional horn prior to resection, chromotubation is performed. During resection of the noncommunicating uterine horn, it is important to identify and ligate the remnant uterine vessels.

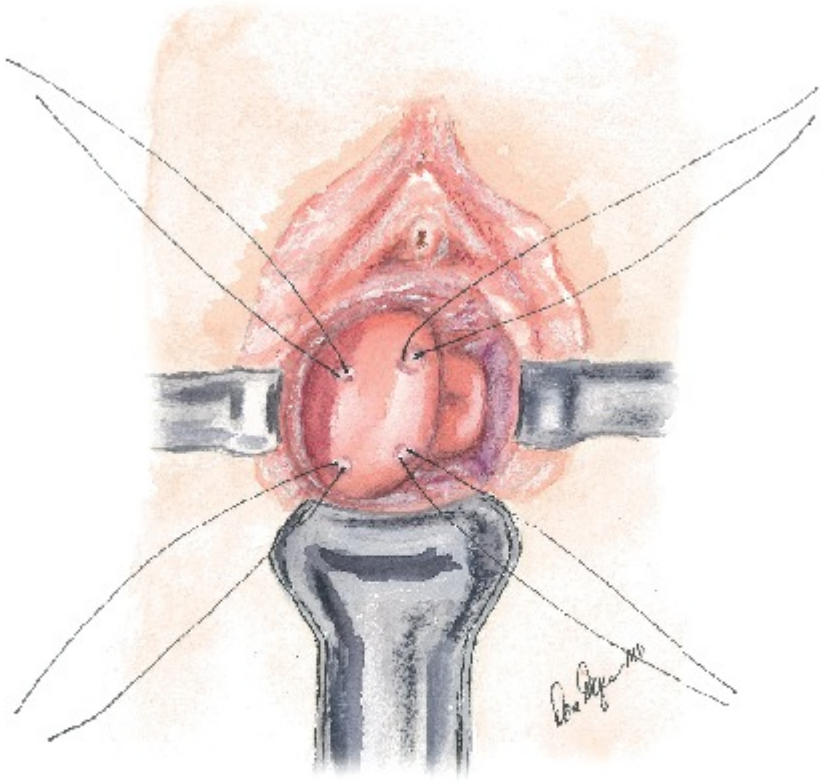
## Class III Anomalies

This class involves uterine duplication, but specifically, the duplicated side in this situation includes the presence of a hemivagina with an obstructed longitudinal septum. This anomaly is referred to as obstructed hemivagina with ipsilateral renal anomaly (OHVIRA). Patients will present with a history of normal menarche and progressively worsening pelvic pain. A small subset of individuals will have a microperforation of the hemivaginal septum. In this situation, it is not uncommon for diagnosis to be delayed since both sides will allow for menstrual egress and pelvic pain may not be the presenting symptom. Instead, individuals present with chronic vaginal discharge or prolonged menses. Rarely, individuals with a septal microperforation are at risk for pelvic inflammatory disease. For adolescents presenting with pelvic pain, it is ideal to obtain an ultrasound, followed by MRI for confirmation of the pelvic anomaly. Confirming the distance of the obstructed side from the perineum is just as important as determining the septal thickness.

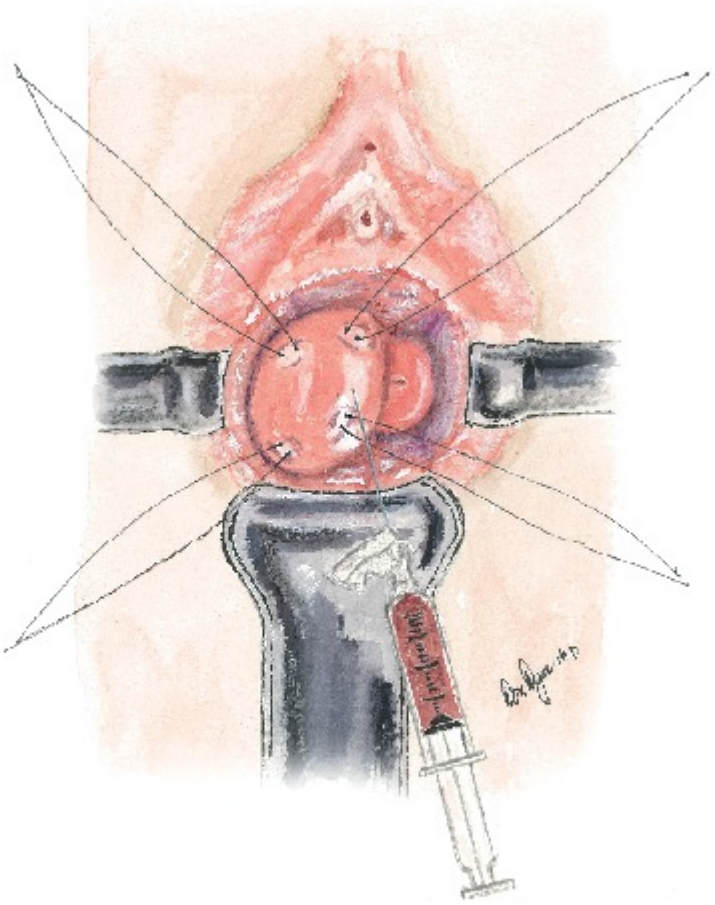
This condition is frequently associated with ipsilateral renal anomalies. It is important to assess the urologic anatomy since among patients diagnosed with solitary kidney, 9% will have an ectopic ureter, of which 89% drain into the hemivaginal space. In this situation, gynecologic surgical intervention should be planned in conjunction with a urology consultant. The surgical approach to remove the obstructed longitudinal vaginal septum involves detailed knowledge of the anatomy (**FIG. 42.7**). Potential complications include bowel and bladder injury; therefore, it is important to understand the anatomy and distance from the perineum to the obstructed hemivagina.



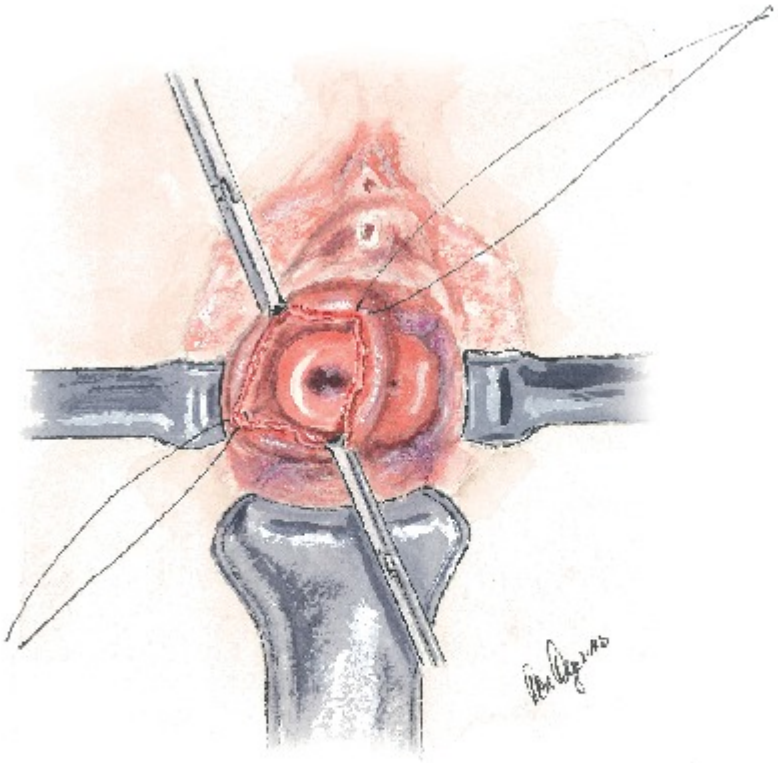
**A** Bulging right hemivagina and left cervix



**B** Traction sutures placed on the hemivaginal bulge

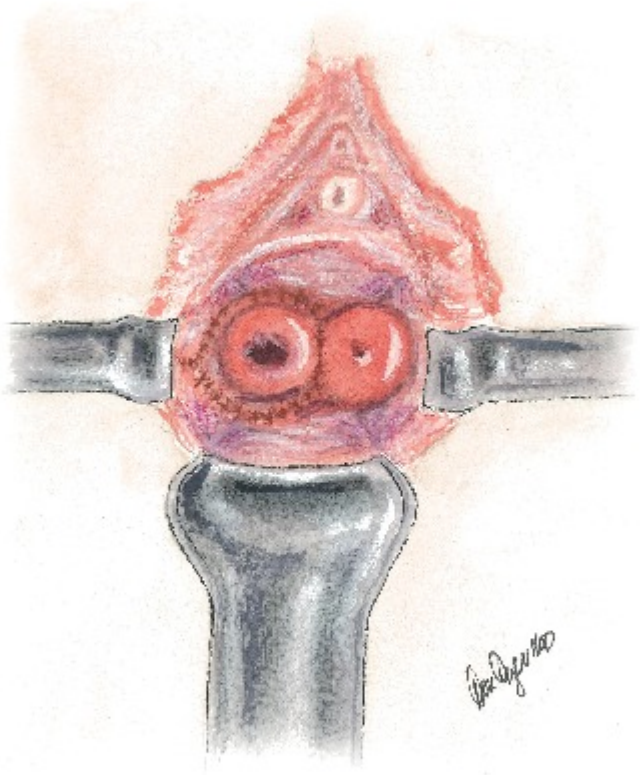


**C** Needle mapping of the hemivaginal space with traction sutures in place



**D** Following lateral incision, once needlemapped, the septal edges are grasped and hematocolpos removed

**E** Once septum removed
the right cervix is exposed



**F** Vaginoplasty performed to anastomose right hemivagina to normally developed left vagina

**FIGURE 42.7** Resection of obstructed longitudinal vaginal septum in OHVIRA. **A.** Bulging right hemivagina and left cervix. **B.** Traction sutures placed on the hemivaginal bulge. **C.** Needle mapping of the hemivaginal space with traction sutures in place. **D.** Following lateral incision, needle is mapped, the septal edges are grasped, and hematocolpos is removed. **E.** Once septum is removed, the right cervix is exposed. **F.**

Vaginoplasty is performed to anastomose right hemivagina to normally develop left vagina. (Redrawn illustrations courtesy of Dr. Donald Dyer.)

A Foley catheter should be placed in the urethra to identify this structure and ensure that it is well away from the field of dissection. A speculum or Deaver retractor is then placed in the vagina to expose the area of obstruction. Using traction sutures, the distal septal margins are outlined at 12, 3, 6, and 9 o'clock. With outward traction distally, a 16- or 18-gauge spinal needle can be placed into the obstructed space to confirm the presence of hematocolpos fluid and that the correct space has been found. Using the needle as a guide, a scalpel is used to incise the septum and then extend the incision laterally. The septal edge is grasped with an Allis clamp, while the space filled with hematocolpos is decompressed using the suction. The opening is enlarged bluntly with a Kelly clamp. Excess septum is removed with the use of a cautery device or a traditional cut, clamp, and tie method. With the excess septum removed in order to anastomose the normal vagina to create a "Y" vagina, interrupted sutures are placed to approximate the hemivagina to the normal vagina circumferentially. It is important to avoid running these sutures as doing so can result in vaginal stricture formation. It is also important to ensure that an adequate amount of septum has been removed to prevent stricture formation, which results in an ascending infection. At the end of the procedure, both cervices should be visualized vaginally (see **FIG. 42.7**).

When a microperforation in the septum does not allow for development of a hematocolpos and bulge effect, the septal margins are difficult to determine as is the distance from the proximity to the bladder and rectum. Vaginoscopy is very useful to elucidate the location of the microperforation (**FIG. 42.8**). Once the location of the microperforation has been determined, the opening can be canalized with a dilator or a Foley balloon. A balloon is very helpful for traction as with balloon distension, the cavity margin is demarcated. The

balloon also allows for identification of a starting point for septal resection. Rarely, a microperforation will not be seen in the vagina but may occur at the level of the cervix. This can delay diagnosis and require hysteroscopy to evaluate the cervical canal. In order to map the space, blue dye or other sterile dye medium is injected vaginally to identify the small microperforation. In a similar fashion, once the space is identified, incisions are made to enlarge the opening followed by serial resection of excess septal tissue as described above. Finally, interrupted sutures are placed in a circumferential fashion.

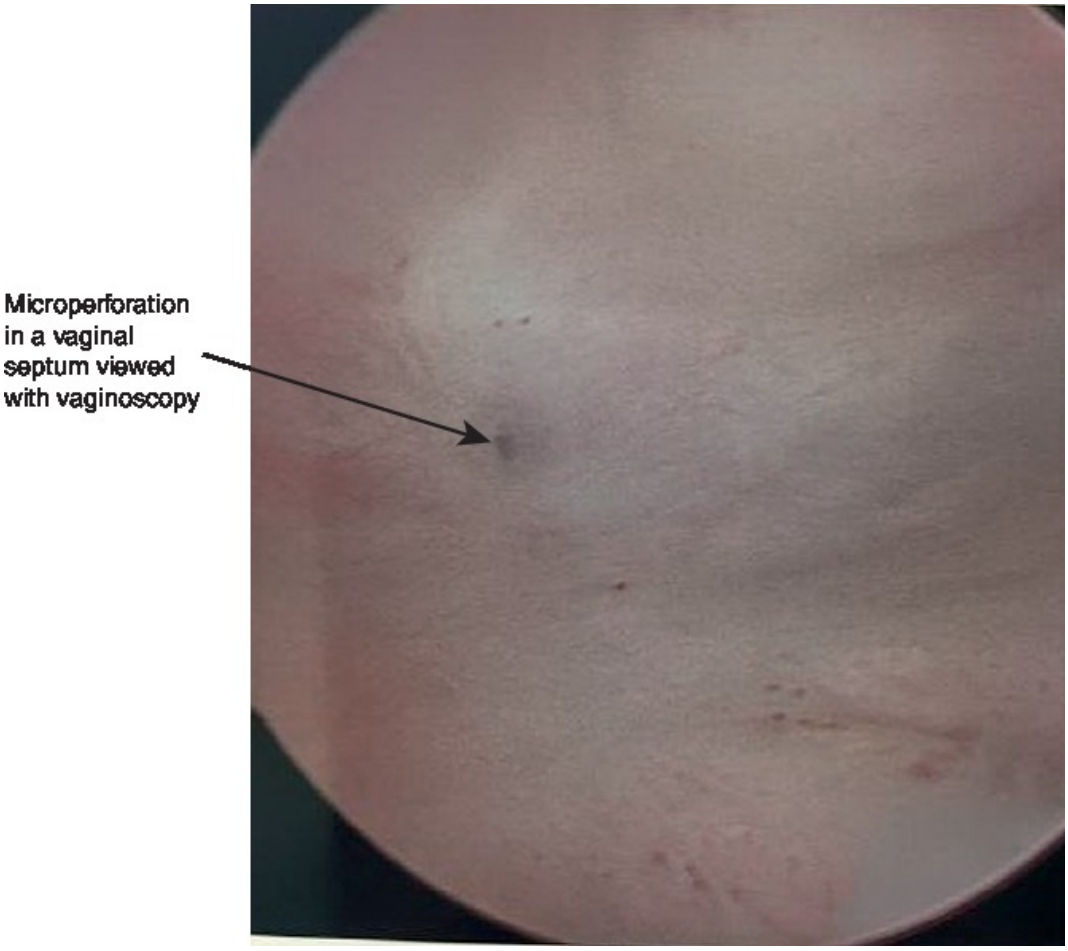



**FIGURE 42.8** Vaginoscopy demonstrating microperforation.

# SURGERY FOR NONOBSTRUCTIVE ANOMALIES

Nonobstructive conditions present in adolescence as delayed puberty without obstructive symptoms or in adult women as an incidental finding during a surgical procedure or the course of an infertility workup. Menstrual abnormalities may be minor or present as primary amenorrhea, recurrent pregnancy loss, dyspareunia, or other reproductive abnormalities.

## Class I Anomalies

One in 5000 females will have MRKH or uterovaginal aplasia, a 46XX karyotype, and an external female phenotype. The majority of patients will present with primary amenorrhea. At the time of diagnosis, a discussion about future needs is important. This discussion should focus on fertility concerns, psychological concerns, and vaginal lengthening with dilation. Vaginal dilation is more than 90% successful and was first described by Frank in the 1930s. Vaginal dilation is recommended as initial therapy. There is no critical time by which one must dilate as it is dependent on the maturity of the patient and her readiness. Dilation is performed progressively and gradually to stretch the vaginal dimple. This technique was expanded to include the Ingram method in the 1980s, using gravity as additional measure through use of a bicycle seat affixed with a vaginal dilator. The major principle behind the vaginal dilator is similar to tissue expansion principles utilized by plastic surgery, simply with reverse and intermittent expansion. Vaginal dilation may be accomplished over several months or may take several years. It is recommended that patients perform dilation for 30 minutes each day. While performing dilation, patients can listen to music, take a warm bath or shower to help with vaginal dimple tissue pliability, and use topical agents, such as lidocaine jelly or estrogen cream. The process of sexual activity can also result in vaginal lengthening over time.

When vaginal dilation fails, surgical creation of a neovagina is the next treatment option. A number of techniques are available such as the McIndoe procedure and its variations and the Williams procedure. Use of a particular technique is best individualized to each patient (**e-TABLE 42.1**). Regardless, the main surgical tenet is that a neovaginal space must be created between the bladder and the rectum, for placement of graft tissue (full-thickness or split-thickness skin, bowel, labial flaps, buccal mucosa, peritoneum) (**FIGS. 42.9 and 42.10**).

## e-TABLE 42.1
## Vaginoplasty for Vaginal Agenesis When Dilation Fails

| VAGINOPLASTY TECHNIQUE | PROCEDURE | ADVANTAGES AND DISADVANTAGES |
|---|---|---|
| Skin | Involves harvesting of skin (usually by plastic surgery) for placement around a vaginal mold that is set in the neovaginal space | *Advantages*: Utilizes patient tissue, so no risk of rejection<br>*Disadvantages*: Must be in recumbent position for 7 d for the graft to take in the neovaginal space. Must use and mold for 6 wk postop and dilate after the procedure until regularly sexually active |
| Labial flaps | Involves rotation of labia minora or majora flaps depending on redundancy of tissue available | *Advantages*: Utilizes patient tissue, so no risk of rejection. No need for postop dilation or vaginal mold use in many cases<br>*Disadvantages*: Not as anatomic. Only lengthens the very distal vagina. Hair-bearing skin |
| Bowel | For patients with no other graft option, rectum or small bowel has been used. This is harvested by general surgery in all cases as it is critical to maintain the viability of the vascular pedicle | *Advantages*: Utilizes patient tissue, so no risk of rejection. No need for postdilation of vaginal mold use<br>*Disadvantages*: Critical to have adequate bowel prep preop. Mucous discharge is a common complaint by patients as it may collect in the bowel neovagina and result in odor. Risk of tissue prolapse |
| Buccal mucosa | Very similar characteristics to vaginal mucosa. Involves harvesting of a mucosal graft from the inner cheek by plastic surgery or otolaryngology | *Advantages*: Utilizes patient tissue, so no risk of rejection. Heals quickly at the harvest site. Very similar appearance to vaginal mucosa once healed<br>*Disadvantages*: The harvest site in the mouth can vary in size; therefore, the surface area to cover may be limited by the amount of buccal tissue available. Need to use a vaginal mold post and dilate long term |
| Davydov | Involves the use of peritoneum to line the neovaginal space | *Advantages*: Utilizes patient tissue, so no risk of rejection. Can be accomplished with a combination laparoscopic and vaginal approach<br>*Disadvantages*: Requires use of a mold postop. Granulation tissue can form in some cases and result in unwanted bleeding. Need to dilate long term. The surgery involves a lengthy dissection to create the neovaginal space, free up peritoneum from the pelvis, and sew the apex closed from the abdominal side. Requires a gynecoid pelvis and no history of major abdominal surgery to allow for enough peritoneum to line the space and for ease of moving it down into the neovaginal space. Requires special training to perform the procedure |
| Vecchietti | Involves the use of native vagina, created through stretching the vaginal dimple over a short time frame | *Advantages*: Utilizes native vaginal tissue. Same principle as dilation, only quicker. May be used in patients with prior abdominal surgery. Involves laparoscopic and vaginal approach. Typically, a quick procedure<br>*Disadvantages*: Requires special training to perform the procedure. Risk of iliac vessel injury |

From Karateke A, Haliloglu B, Parlak O, et al. Intestinal vaginoplasty: seven years' experience of a tertiary center. *Fertil Steril*. 2010;94(6):2312-2315; Kirk EP,

Chuong CJ, Coulam CB, Williams TJ. Pregnancy after metroplasty for uterine anomalies. *Fertil Steril*. 1993;59(6):1164-1168; Lanza H, Balestrelli J, Pastoni D, Molero JF. Vaginoplasty technique using vulvoperineal flaps. *Aesthetic Plast Surg*. 2014;38(1):164-168; Mansouri R, Dietrich JE. Post-operative course and complications after pull-through vaginoplasty for distal vaginal atresia. *J Pediatr Adolesc Gynecol.* 2015;28(6):433-436; Mastrolla SA, Baumfeld Y, Hershkovitz R, et al. Bicornuate uterus is an independent risk factor for cervical os insufficiency: a retrospective population-based cohort study. *J Matern Fetal Neonatal Med.* 2017;30(22):2705-2710.

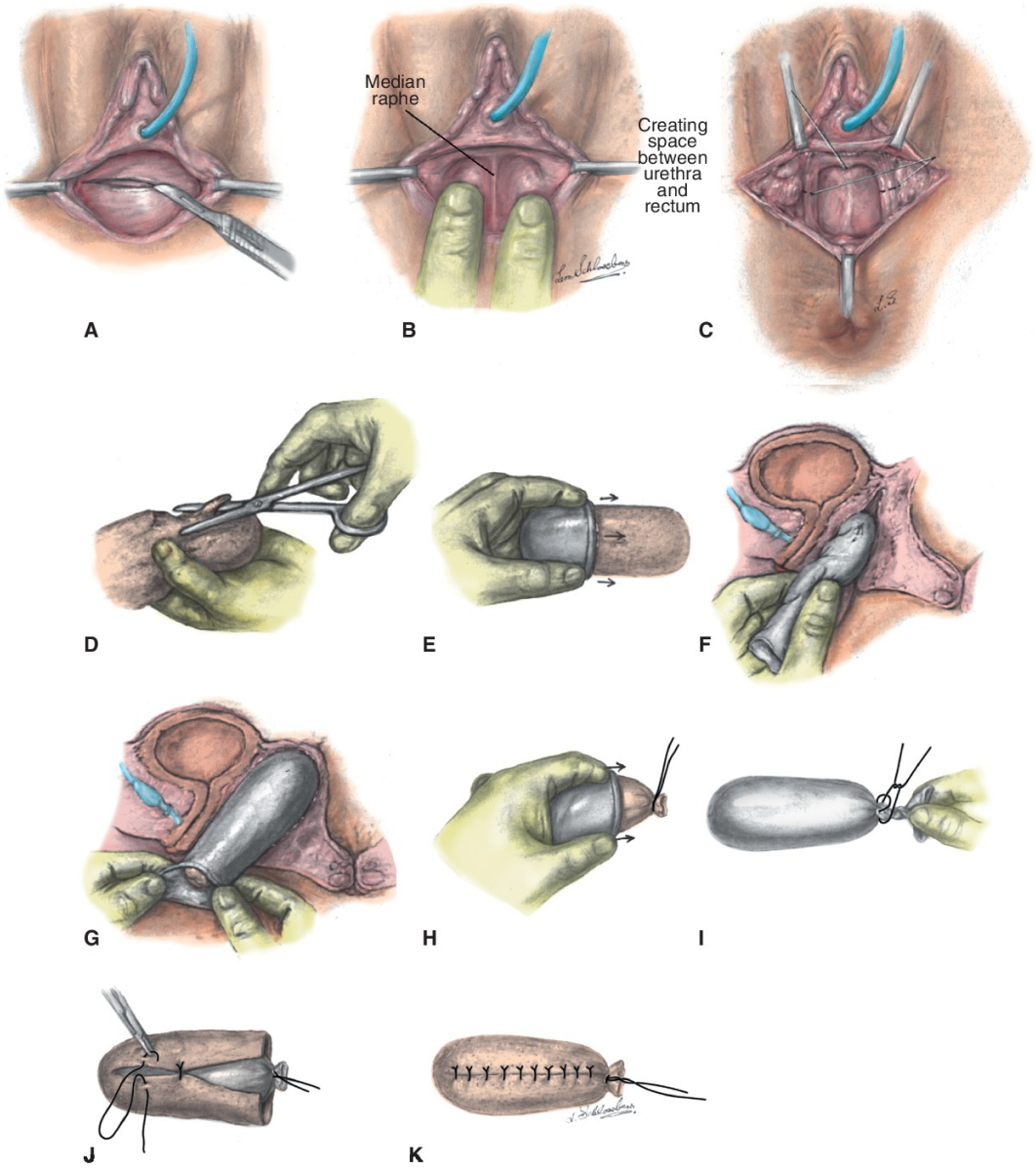


**FIGURE 42.9** McIndoe procedure. **A.** A transverse incision is made in the apex of the vaginal dimple. **B.** A channel can usually be dissected on each side of the median raphe. The median raphe is then divided. Careful dissection prevents injury to the bladder and rectum. **C.** A space between the urethra and bladder anteriorly and the rectum posteriorly is dissected until the undersurface of the peritoneum is reached. Incision of the medial margin of the puborectalis muscles will enlarge the vagina laterally. **D-K.** Counseller-Flor modification of the McIndoe technique. **D.** A form is cut from a foam rubber block. **E.** A condom is placed over the form. **F.** The form is compressed and placed into the vagina. **G.** Air is allowed to expand the foam rubber, which accommodates to the neovaginal space. The condom is closed and the form removed. **H.** A second condom is placed over the form and **I.** tied securely. **J.** The graft is then sewn over the form with interrupted 5-0 nonreactive sutures. **K.** The undersurfaces of the sutured edges of the graft are exteriorized. The vaginal form is ready for insertion into the neovagina.

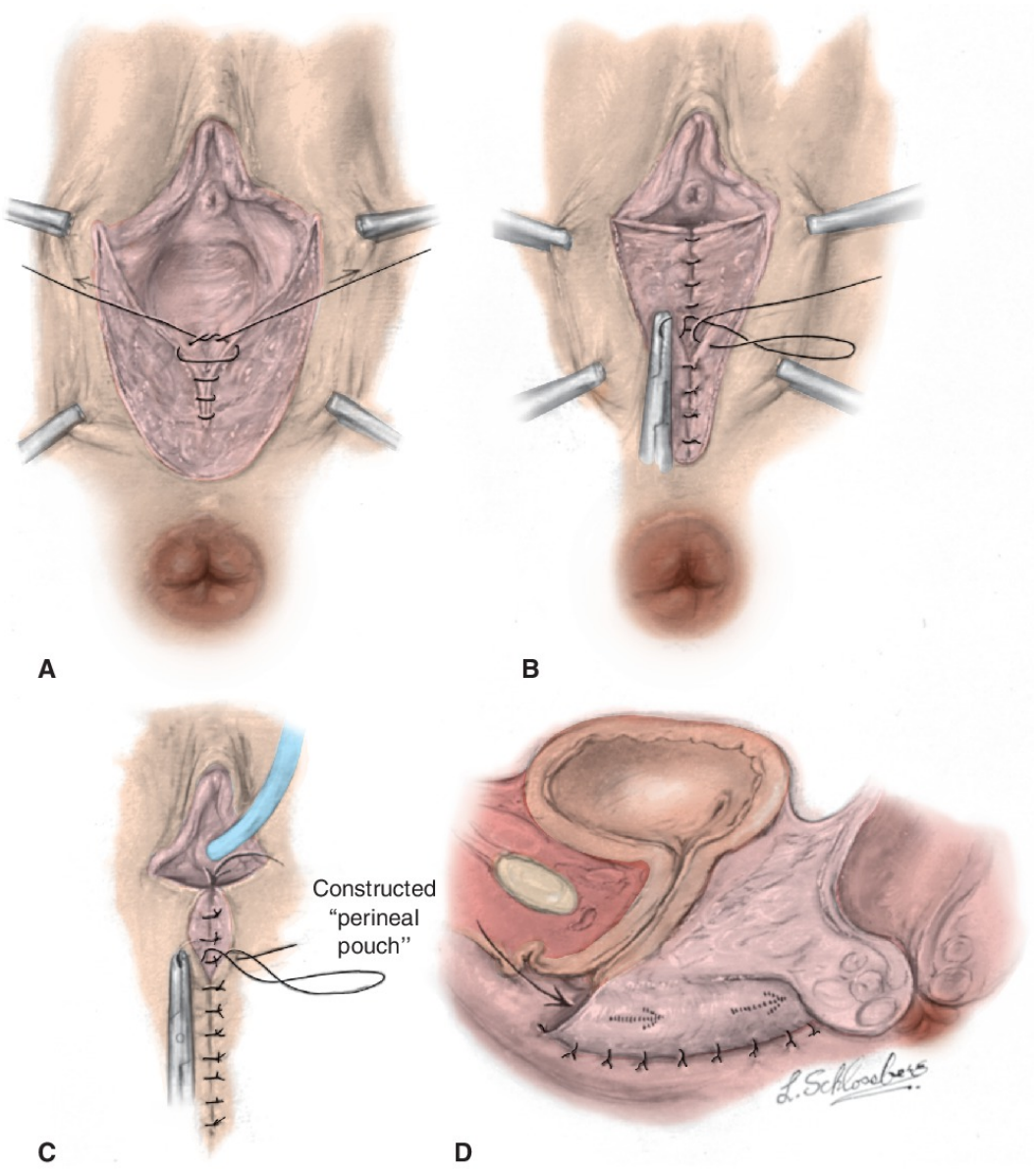
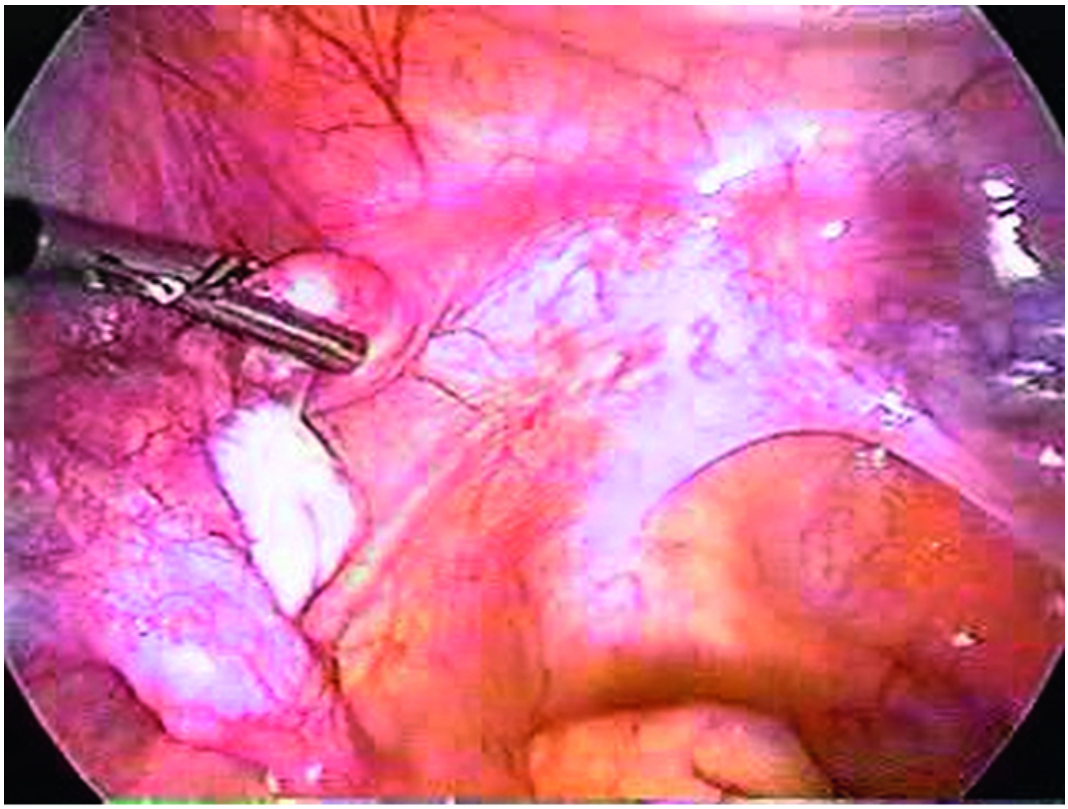
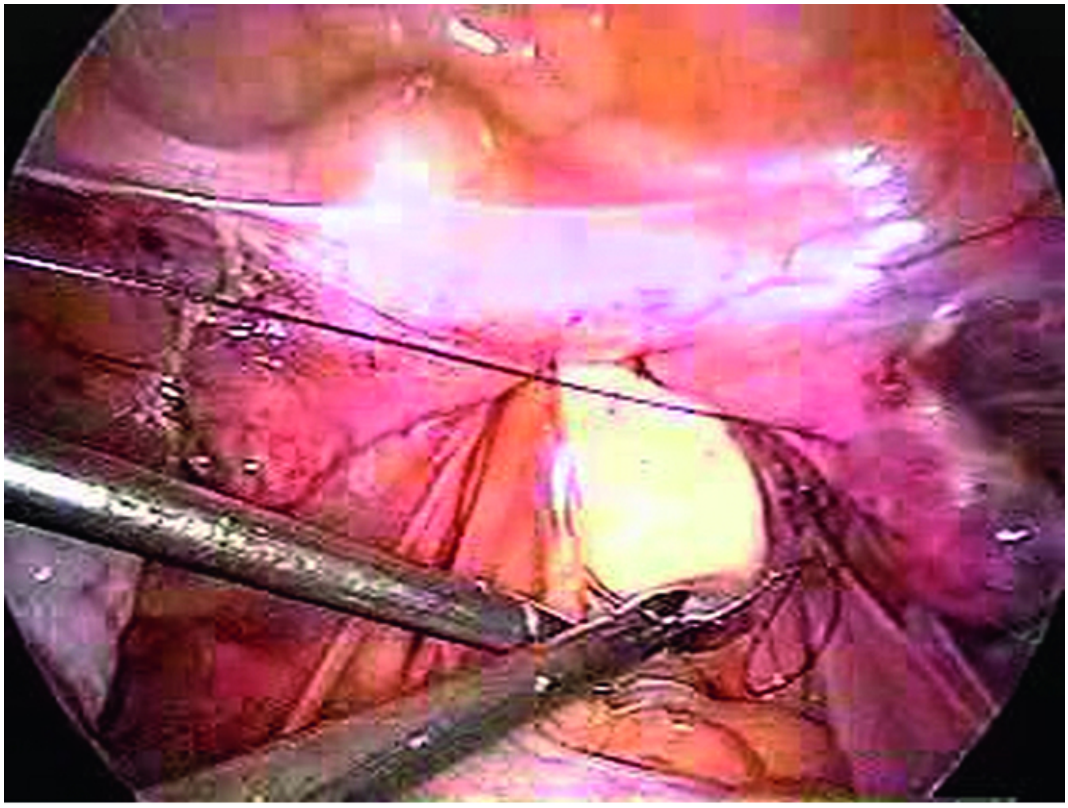



**FIGURE 42.10** Williams vaginoplasty. Vulvar and perineal tissue are sutured together to create a perineal pouch. **A-C.** No. 3-0 polyglycolic acid sutures can be used throughout to close both inner and outer skin margins and the tissue between. **D.** The entrance to the pouch should not cover the external urethral meatus.

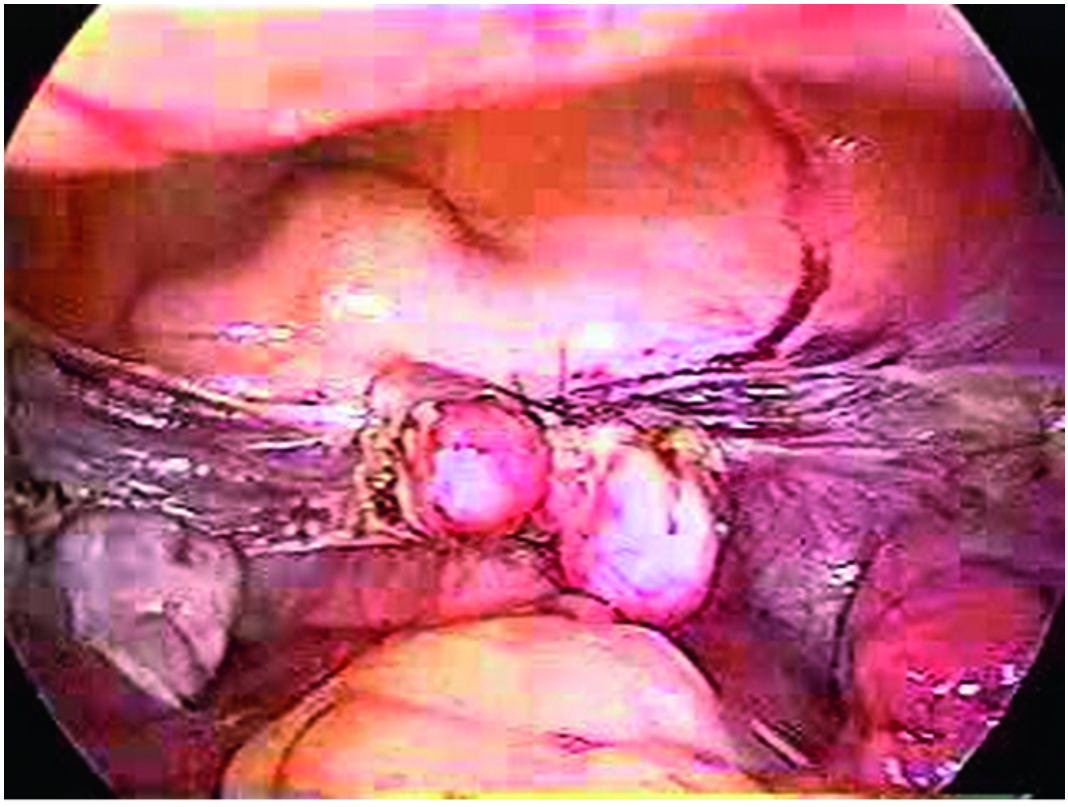
The Davydov neovagina procedure utilizes the peritoneum (**FIG. 42.11**). One modification for the Davydov compared to other graft techniques is that of closing the vaginal apex over the vaginal mold following the dissection of the neovaginal space, since the neovaginal space from the perineum communicates to the abdomen until the apex is closed. Prior to dissection of this space, a Foley catheter should be placed in the urethra and ensure that it is well away from the field of dissection.



**A**



B



C

**FIGURE 42.11** **A.** Left remnant uterine horn in patient with MRKH. **B.** Vesicorectal space dissection completed with placement of a vaginal mold from below. This allows for planning for apical closure with peritoneum. **C.** Davydov closure of the vaginal apex with remnant uterine horns drawn medially for apical support.

In the case of the Vecchietti procedure, the device, called an "olive," placed at the perineum, provides progressive dilation of the small portion of native vagina between the bladder and rectum. The neovaginal space is created through progressive traction over 4-7 days. It is important to establish whether the distance between the urethra and rectum is enough to accommodate the width of the "olive" device. Potential complications of all neovagina procedures include bowel and bladder injury; therefore, it is important to have a clear understanding of the anatomy and estimation of the space between the bladder and rectum and whether it will accommodate the neovagina.

Uterine transplant is the newest surgical option available to women with this anomaly. It must be stressed that this procedure is still experimental due to the significant morbidity risks to the donor and the recipient. Nonetheless, for women living in countries where gestational surrogacy is illegal, this may be the only option to consider.

## Class II Anomalies

A small percentage of patients with a unicornuate uterus will present with a nonfunctioning uterine horn or a communicating functional horn. In both situations, pain is not typically a presenting complaint. The nonfunctioning horn may be in fact identified incidentally on an imaging study, best seen on pelvic ultrasound (**FIG. 42.12**) or during

the course of another abdominal surgery. Because these patients do not present with pain, the remnant can be left in place, avoiding invasive intervention. In the case of a communicating functioning uterine horn, the risk for ectopic pregnancy is 1 in 76 000 and removal of this horn is recommended. This can usually be resected laparoscopically, followed by oversewing the previous area of connection to cover the defect once the horn is removed.

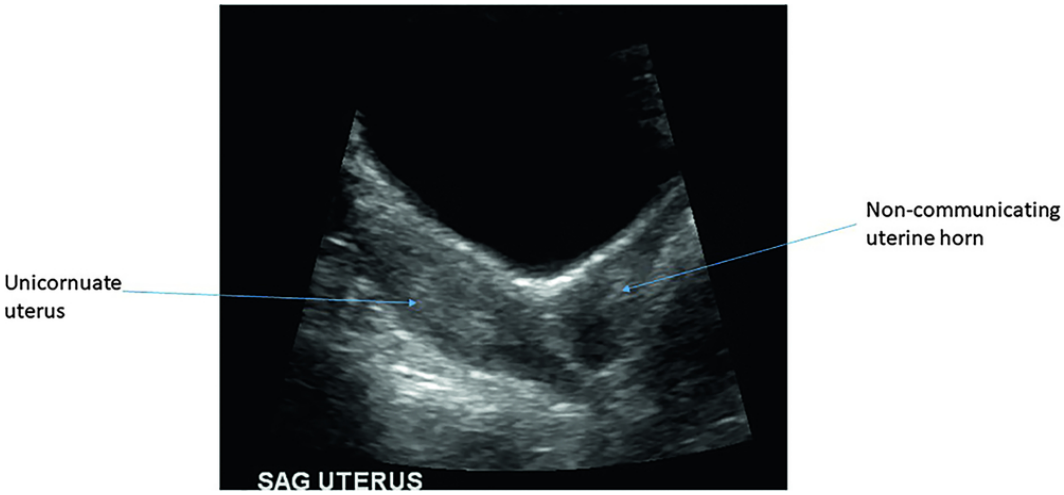



**FIGURE 42.12** Pelvic ultrasound of unicornuate uterus with noncommunicating uterine horn.

## Class III Anomalies

In this category, there is duplication of the uterus and vagina without outflow obstruction, and therefore, the typical presentation may vary from absence of symptoms to difficulty with tampon placement or dyspareunia due to the presence of a nonobstructed longitudinal vaginal septum.

Although attempted many decades ago, unification procedures, such as the Strassman unification (**FIG. 42.13**), did not improve obstetric outcomes. Due to the associated morbidity with the procedure itself, this practice was discontinued.

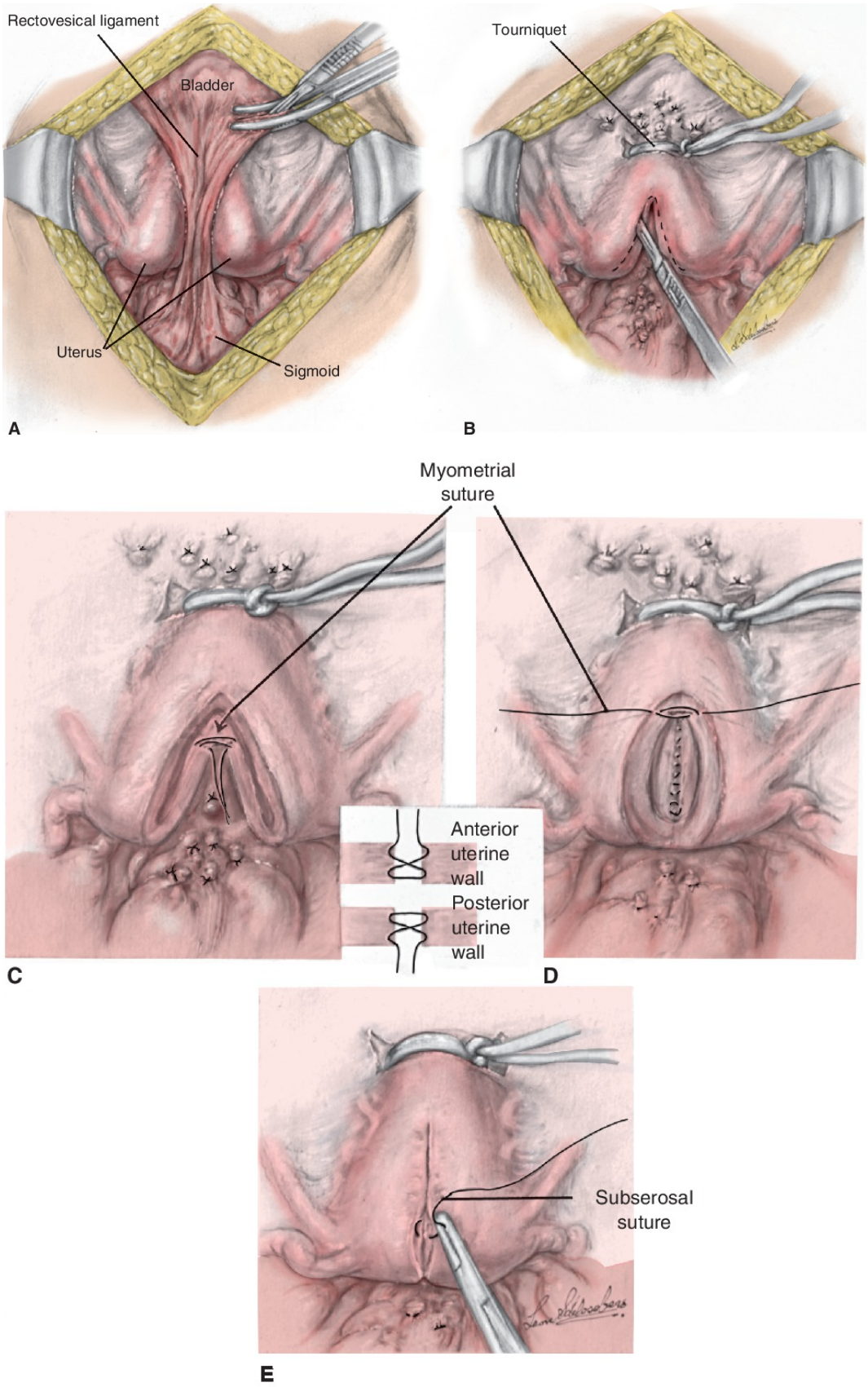

Rectovesical ligament
Bladder
Uterus
Sigmoid
A
Tourniquet
B
Myometrial suture
Anterior uterine wall
Posterior uterine wall
C
D
Subserosal suture
E

**FIGURE 42.13** Strassman unification. **A.** If a rectovesical ligament is found, it should be removed. **B.** An incision is made on the medial side of each hemicorpus and carried deep enough to enter the uterine cavity. The edges of the myometrium will evert to face the opposite side. **C and D.** The myometrium is approximated by the use of interrupted vertical figure-of-8 3-0 polyglycolic acid sutures. One should avoid placing sutures too close to the interstitial portion of the fallopian tubes. **E.** A continuous 5-0 polyglycolic acid subserosal suture is used as a final layer. Tourniquets are removed, and defects in the broad ligament are closed.

To aid with ease of tampon placement or treat dyspareunia, the longitudinal vaginal septum can be removed. This is accomplished with the use of clamp/cut excision technique or resection with cautery. With removal of the entire vaginal septum, the right and left vaginas may be unified. It can be useful to place a tenaculum on one of the cervices to provide downward traction and for ease of access as the apex sites are sewn. Starting proximally at the vaginal apex is one option where interrupted sutures are placed, sewing right and left hemivaginal mucosa together at the apex, on the anterior vaginal wall and posterior vaginal wall. These sutures are placed ~1 cm apart from one another. Another option is to begin distally at the anterior or posterior vaginal wall, using interrupted sutures, but then leaving a suture tail to tag with a hemostat, which allows for traction to better visualize the more proximal site to be sewn. It is important to avoid running these sutures as doing so can result in vaginal

stricture formation. It is important to have a clear understanding of the length of the longitudinal septum and its relation to bowel and bladder to avoid injury to these areas (**BOX 42.3**).

## BOX 42.3 STEPS IN THE PROCEDURE

### Vaginoplasty for Longitudinal Vaginal Septum

- Place a Foley bulb into the urethra for identification.
- Identify the margins of the septum proximally, distally, anteriorly, and posteriorly.
- Excise the septum.
- Unify right and left halves of the vagina anteriorly, both proximally and distally using absorbable interrupted sutures.
- Unify right and left halves of the vagina posteriorly, both proximally and distally using absorbable interrupted sutures.
- Place a vaginal mold.

# Class IV Anomalies

Class IV anomalies include duplication of the fundal portion of the uterus. Unification procedures such as those previously recommended for management of didelphys uteri procedures for bicornuate uteri did not improve obstetric outcomes (see **FIG. 42.13**). Studies suggest that women with this type of anomaly may be at higher risk for incompetent cervix. Although there is no need to place a cerclage at the time of diagnosis, it is important to counsel patients about their anomaly as their obstetrician may need to discuss the risks and benefits of cerclage placement at the time of pregnancy.

# Class V Anomalies

The septate uterus is one reason women may be seen by infertility specialists, specifically due to recurrent pregnancy loss. Uterine

septa may be complete, even involving the cervix, or partial, involving the fundal to miduterine portion of the uterus. The standard treatment is removal of the uterine septum hysteroscopically with the use of endoscopic scissors or a cautery device. Removal of the septum results in improved pregnancy outcomes, and the procedure is well tolerated by most women.

It is ideal to remove the septum where present within the cervix and uterus to allow for ease of access in the future and to improve pregnancy outcomes. Most women will not present with pain or other symptoms; therefore, the timing of this procedure is determined by the patient. Potential complications of this procedure include fluid overload related to hysteroscopic fluid use and cervical damage. Uterine perforation can occur if the exact position and length of the uterine septum are not well understood.

There has been wide variation in the practice of postprocedure intrauterine balloon stenting to reduce the development of adhesions. A randomized study evaluated the use of balloon stenting following hysteroscopic resection and found no differences in uterine results at 3 months and no differences in reproductive outcomes. More recently, a pilot study was performed to assess septum removal using laser resection. This technique shows similar promising results, with the potential for fewer postoperative intrauterine adhesions.

Rarely, a uterine septum will be associated with bicollis or a duplicated cervix. In this situation, in order to remove the uterine septum adequately, it is necessary to map out the space hysteroscopically. For resection, it may be necessary to place a Foley balloon into one cervix to allow for ease of identification of the septum hysteroscopically at the most distal location so as not to damage one cervix during the hysteroscopic resection (see **FIG. 42.14**; **BOX 42.4**).

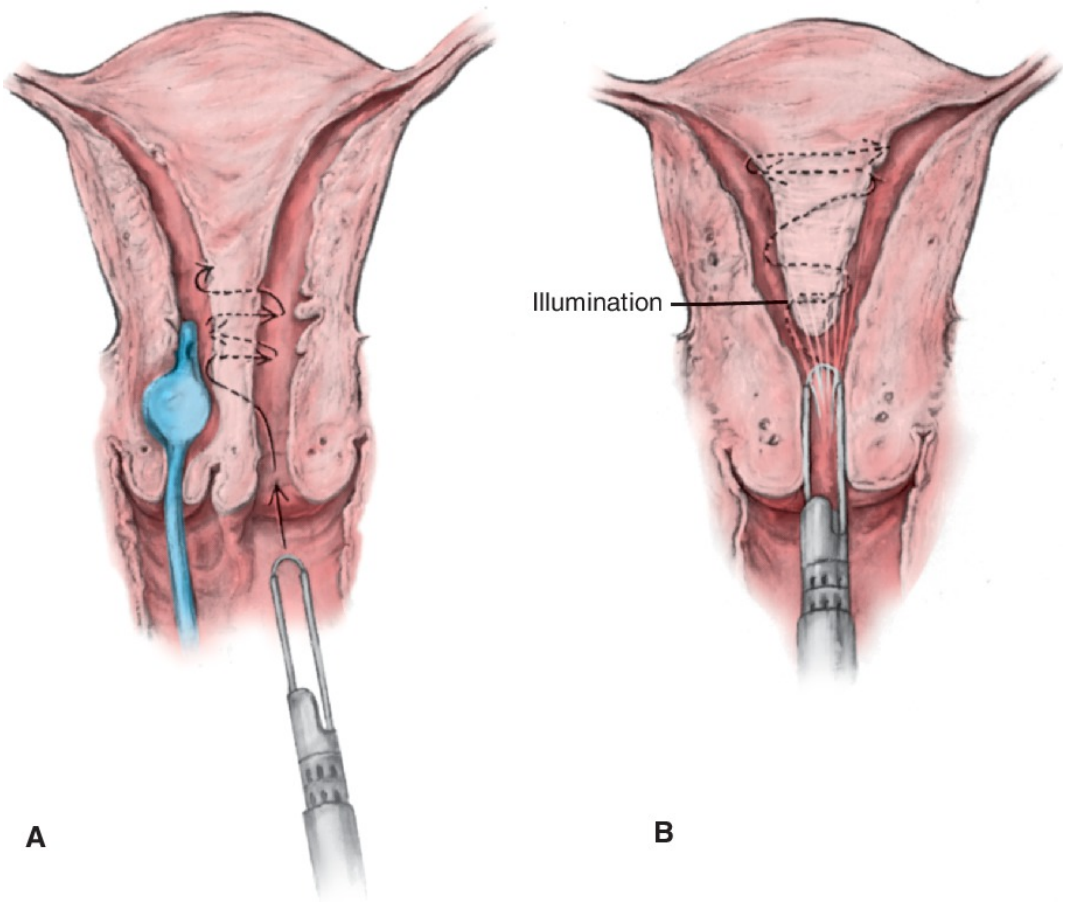



**FIGURE 42.14** Hysteroscopic resection of uterine septum in normal cervix and case of bicollis cervix. **A.** A Foley catheter is placed in one cavity of a complete septate uterus (American Fertility Society class Va uterus). The resectoscope is inserted in the opposite cavity, and the septum is incised until the Foley is visualized. The septum can be easily incised with the resectoscope until both internal os are visible. **B.** A septate uterus with a single cervix. The septum can be

incised with the straight loupe of the resectoscope.

## BOX 42.4 STEPS IN THE PROCEDURE

### Uterine Septum (Partial or Complete)

### Hysteroscopic Metroplasty

- Place a Foley bulb into the urethra for identification.
- Perform diagnostic hysteroscopy to identify the margins of the septum proximally, distally, anteriorly, and posteriorly.
- If a bicollis is present, place a Foley balloon into one cervix for ease of identifying septal margins.
- Excise the septum hysteroscopically.
- May place an intrauterine balloon or opt not to use a balloon.

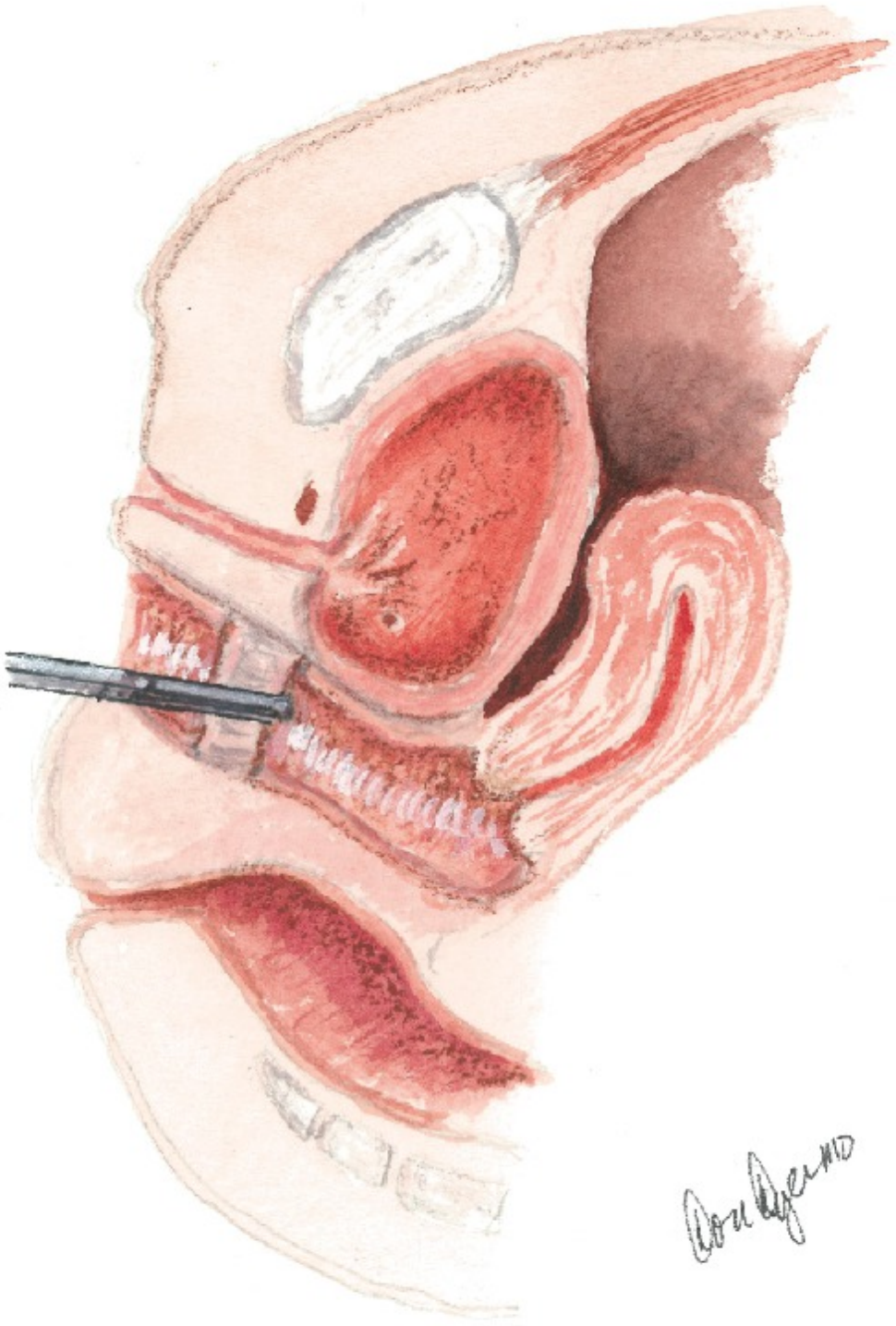
## Class VI Anomalies

The arcuate uterus has a small cleft in the fundus not extending more than 1 cm deep into the myometrium. This is a normal variant, does not result in adverse obstetric outcomes, and does not require surgical intervention.

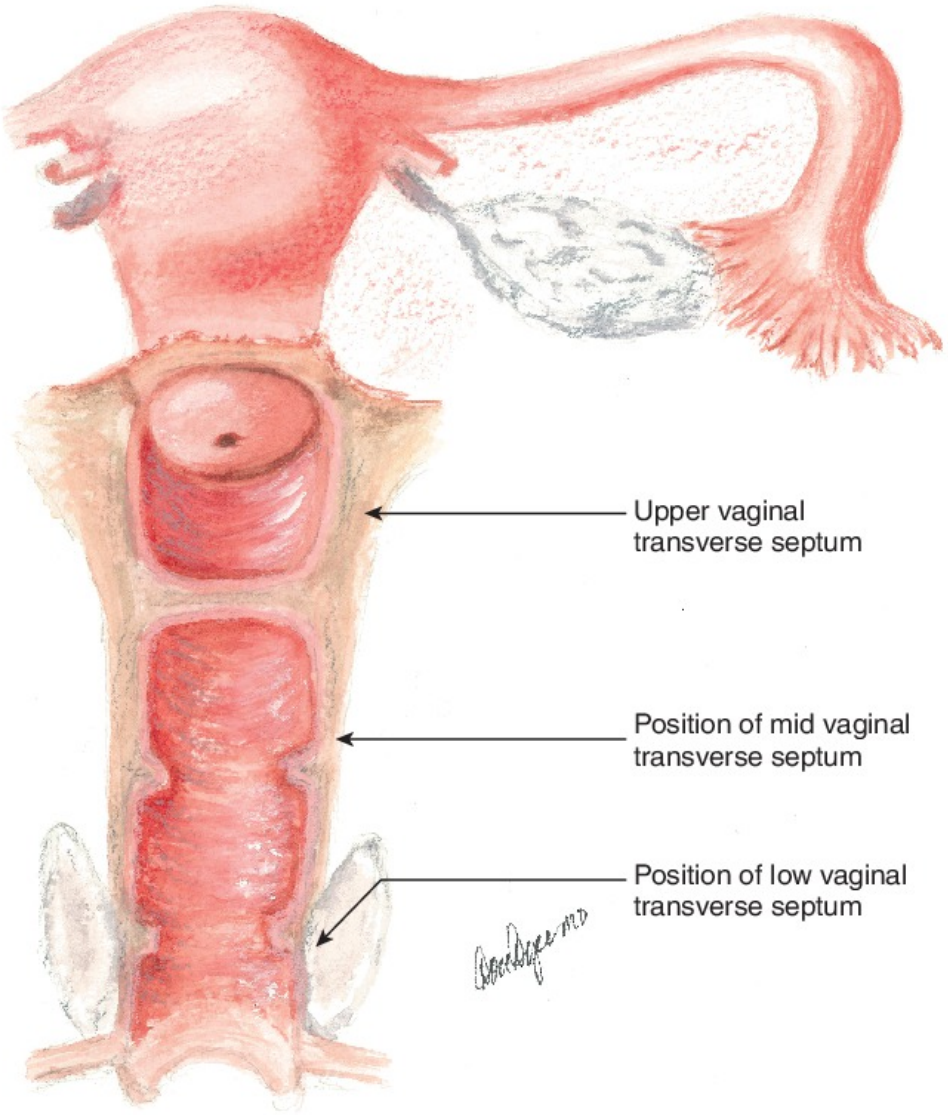
# MANAGEMENT OF OTHER OUTFLOW TRACT ANOMALIES

A transverse vaginal septum occurs in 1/72 000 females. This occurs due to maldevelopment of the urogenital sinus as it fuses with müllerian structures, rather than abnormal müllerian development. In this situation, the transverse septum may be in the lower vagina, mid vagina, or upper vagina (**FIG. 42.15**). The septa located in the upper

and middle vagina are the most common and are also the most difficult to repair. The septum may be thin or thick.



**A** Sagittal view transverse vaginal septum




**B** Coronal view transverse vaginal septum

**FIGURE 42.15** Sagittal and coronal views of transverse vaginal septum. **A.** Sagittal view of transverse vaginal septum. **B.** Coronal view of transverse vaginal septum. (Redrawn illustrations courtesy of Dr. Donald Dyer.)

Resection involves similar principles as previously discussed in the section regarding vaginal septum. Traction sutures are placed in all four quadrants. With sutures on tension, the more proximally vaginal space can be entered with use of an 18-gauge spinal needle. Once the correct space has been located, through confirmation of drainage of hematocolpos fluid, a scalpel is used to cut down on top of the needle in transverse fashion. This space is extended laterally with a clamp and the space drained to visualize the septum and the more proximal vaginal mucosa. The edges of the septum are grasped and resected. A thin septum may be primarily resected with use of traditional cut, clamp, and tie methods or with use of a cautery device. Once fully moved, the upper vagina may be anastomosed to the lower vagina, using serial interrupted sutures in a circumferential fashion. It is important to avoid running these sutures as doing so can result in vaginal stricture formation. For a thick vaginal septum, it is important to understand the thickness as when the septum is >1 cm thick, it is best addressed using a Z-plasty, Y-plasty, or cross-plasty technique. These techniques preserve the mucosally lined septal tissue, repositioning it to both lengthen and widen the vagina. Traction sutures are important to place here as well. While keeping the space distended, 3-4 distal flaps are created and raised in a Y, Z, or cross-sign approach, such that the thickness of the septum is divided in half. Flaps are then created on the more proximal side and the more distal side separately. The flaps are rotated inward, as demonstrated in this cross-sign approach, which lengthens the vagina, and with interdigitation of the flaps, the vagina is widened. Regardless of the technique utilized, resection of a thick vaginal septum still carries a risk of postoperative stenosis.

A small percentage of individuals with transverse septate may present with a microperforation. Since there is no apparent bulge to map the septal edges, vaginoscopy should be performed to assess the vaginal space, look through the microperforate area into the upper vagina, and assess the septal thickness. It can be useful to place a Foley balloon through the microperforation in this situation to provide traction on the septum (**FIG. 42.16**). This facilitates mapping of septal edges in order to fully resect the tissue when thin and to create flaps when thicker as described above. Potential

complications include bowel and bladder injury and it is important to have a clear understanding of the septal position within the vagina, as well as the septal thickness.

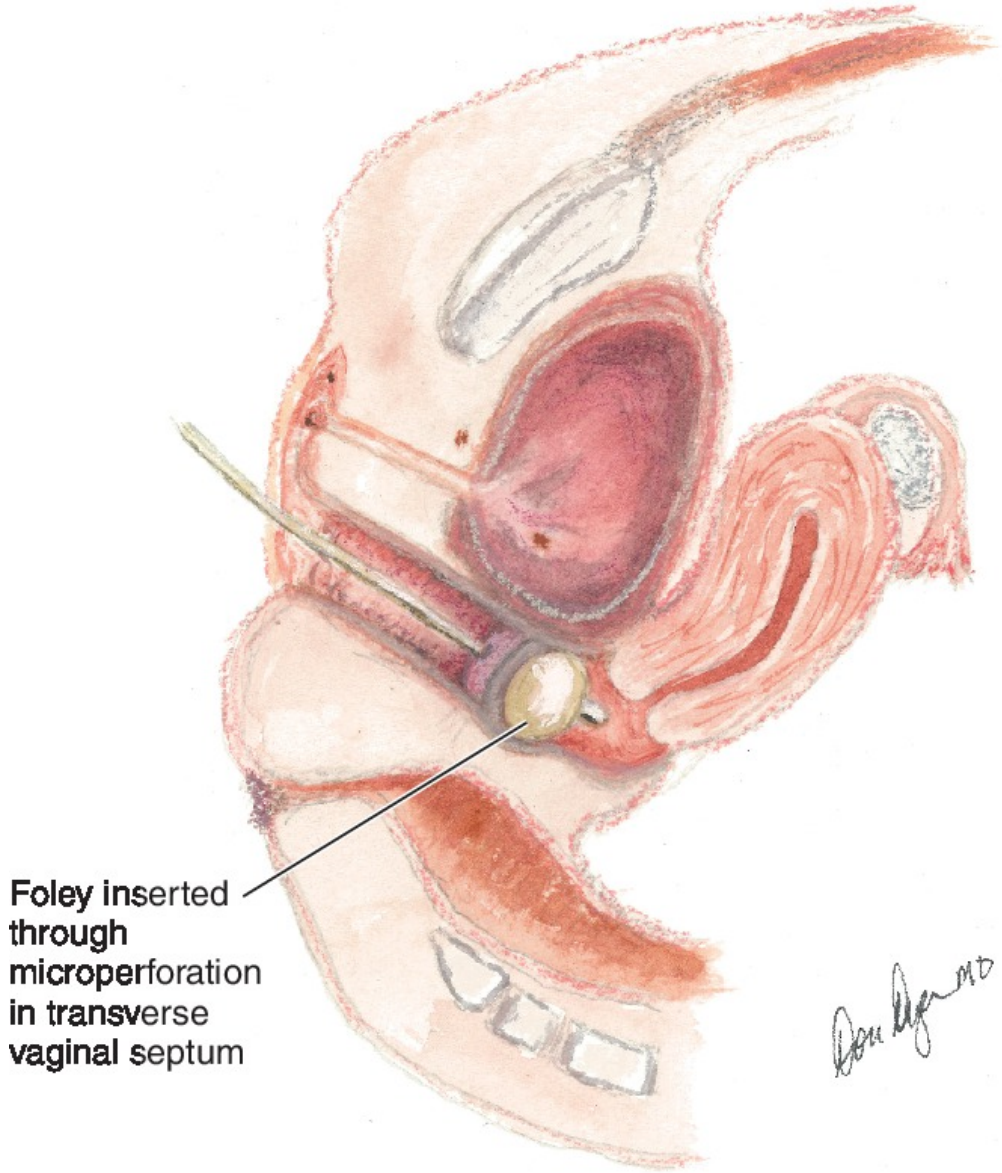



**FIGURE 42.16** Placing a Foley through a microperforation for traction during surgical

excision of a vaginal septum. (Redrawn illustration courtesy of Dr. Donald Dyer.)

## OTHER ASSOCIATED DISORDERS

Müllerian and outflow tract anomalies may present with other anatomic abnormalities. It is important to be aware of these conditions for surgical planning. Approximately 30%-40% of müllerian anomalies are associated with urologic anomalies. This is particularly common in women with OHVIRA, as urologic anomalies are seen in 75%-80% of these individuals. An ectopic ureter is present in these conditions 9% of the time. It is critical to have a full understanding of the anatomy prior to removal of the obstructed uterine septum in these cases. If an ectopic ureter is present, opening the hemivaginal septum could result in ascending infection into the renal remnant on the ipsilateral side. It is also important to involve a urologist if this is suspected in order to time septum removal with removal of the ectopic kidney/ureter. MRI will identify concurrent urologic anomalies and remains the gold standard for imaging.

Among patients with obstructive anomalies of the reproductive tract, endometriosis may be seen in 25%-38% of cases. While patients' symptoms will subside after repair of outflow anomalies, persistence and development of chronic pain may signal evolving endometriosis. Even among patients who may have undergone a diagnostic laparoscopy with normal findings at the time of their initial outflow tract repair, these patients may present later with chronic pelvic pain. This chronic pattern of pain should prompt providers to also think about the development of endometriosis.

Undescended ovaries may also be associated with müllerian anomalies. This can occur in 17% of women with confirmed müllerian anomalies compared to 3% among women with normal uterine anatomy. Ovarian size does not differ between groups. It is important to evaluate the location of the adnexa either on imaging or during the time of a diagnostic laparoscopy as patients with ovaries

located above the pelvic brim can experience pain related to ovulation or cyst formation in a nonpelvic location. While the ovaries may be noted to be malpositioned, the blood supply is normal, and the ovaries function normally and there is no recommendation to move these ovaries to a pelvic location. It is important to counsel patients about this anatomic variance in the event that *in vitro* technology is required and pursued for conception.

## SUMMARY

Müllerian and outflow tract anomalies are important to recognize. The obstructive type of anomaly will result in earlier presentation, typically in adolescence. The nonobstructive anomaly may present later in the adolescent years or incidentally during an infertility assessment. Management of these anomalies involves familiarity with anatomy and associated conditions that may be present. A thorough understanding of the potential risks for complications during and following surgical management is critical for successful treatment.

## KEY POINTS

- Patients with reproductive tract anomalies will most likely see their gynecologist first. It is important to be aware of that lack of menses and pain in young patients may occur due to outflow tract abnormalities.
- Obstructive anomalies typically present at the time of puberty.
- Nonobstructive anomalies can present at puberty, incidentally, or at the time of infertility workup.
- Surgical timing to address certain anomalies is dependent on age of presentation and patient preference.
- Surgical complications can be minimized with careful planning and detailed knowledge of the anatomy.

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# CHAPTER 43

# PEDIATRIC AND ADOLESCENT GYNECOLOGIC SURGERY

Geri Hewitt

**Perioperative Care**

**Examination Under Anesthesia and Vaginoscopy**

**Management of Hymenal Variants**

**Management of Genital Injuries**

**Laparoscopy in the Pediatric and Adolescent Patient**

**Adnexal Surgery**

Preoperative Risk Stratification of Ovarian Masses

Ovarian Cystectomy

Paratubal Cysts

Adnexal Torsion

Oophoropexy

Providing gynecologic care to young girls and adolescent females offers both unique challenges and immense reward. Compared to caring for adult patients, the most significant differences in caring for the younger group are psychosocial development, consent, anatomy, and physiology. Specialists in obstetrics and gynecology are well equipped to manage many common gynecologic conditions presenting in infancy, youth, and adolescence. Whether caring for the reproductive health needs of this population out of passion for

the patients and their diagnoses or based on local resources and practice patterns, specialists in obstetrics and gynecology are essential for this population and their families.

# PERIOPERATIVE CARE

Preoperative counseling of young patients and their families prior to surgery should include a discussion of indication, risks, benefits, and alternative medical or surgical interventions. While laws vary from state to state, most states recognize 18 years as the age of maturity and require parental and/or legal or court appointed medical guardian consent for medical care when the patient is a minor. Ideally, preoperative discussion should include both the parent and/or guardian and the patient, as developmentally appropriate, and include consent from the adult and assent from the minor patient (**TABLE 43.1**). Special consideration regarding consent may be given to pregnant patients younger than 18 years, patients with developmental disabilities over 18 years, or emancipated minors. Since there is state by state variability, support services such as social work and/or legal support may be needed to clarify appropriate consent in complex situations. The impact any surgical intervention may have on future fertility is often a concern and should be proactively addressed. If the planned surgery has a significant risk of decreased fertility or sterilization, involvement of an institutional ethics board may be helpful.

## TABLE 43.1
## Surgical Assent and Consent

| ASSENT | CONSENT |
| --- | --- |
| Child's agreement to medical procedure in circumstances where she is not legally authorized or lacks sufficient understanding for giving consent competently | Approval of the parent or legal representative of a minor child |

Depending on the patient and the procedure, the setting may be an office, procedure center, ambulatory surgery unit, or operating room (OR) in an adult or pediatric hospital. The advantages of attending a pediatric facility include the availability of appropriately sized instruments, anesthesiologists, and staff familiar with perioperative care of youth and teens, pediatric-specific postoperative pain teams, access to pediatric-trained consultants. Other developmentally appropriate support and educational resources including child-life services will also be available.

Many aspects of surgical planning are very similar to adult practice. Determining the required duration of preoperative NPO in consultation with the anesthesia service is important and will vary with patient age and diet. Many pediatric hospitals have implemented ERAS (enhanced recovery after surgery) protocols, which have shortened preoperative NPO times.

The risk of developing venous thromboembolism (VTE) perioperatively is significantly lower in the pediatric population. Sequential compression devices can be used with little risk, and proposed algorithms typically avoid chemoprophylaxis in patients younger than 14 years. For patients deemed high risk due to personal or hereditary risk factors, chemoprophylaxis is given. Appropriate medications, dosing intervals, and follow-up are outlined in the American College of Chest Physicians Evidence-Based Clinical Practice Guidelines.

Use of prophylactic antibiotics to decrease surgical site infections (SSIs) in children and adolescents follows guidelines and indications similar to those in the adult population, except for antibiotic dosing, which is calculated in milligrams per kilogram basis (**TABLE 43.2**).

Pediatric dosing should, however, never exceed recommended adult doses. Regimens typically involve a single dose of first- or second-generation cephalosporin given within 60 minutes of the incision. One dose is typically sufficient, but additional doses may be required based on half-life of the antibiotic, length of the procedure, and in cases with excessive blood loss. For patients aged 5-12 years who require a Foley during surgery, a 10-Fr catheter is appropriate, and for patients older than 12 years, typically a 12-Fr catheter is well tolerated.

## TABLE 43.2
## Pediatric Dosing of Preoperative Prophylactic Antibiotics

| ANTIBIOTIC | PEDIATRIC DOSE | ADULT DOSE |
|---|---|---|
| Cefazolin | 30 mg/kg | 2 g |
| Cefoxitin | 40 mg/kg | 2 g |
| Cefotetan | 40 mg/kg | 2 g |
| Ceftriaxone | 50-75 mg/kg | 2 g |
| Ampicillin-sulbactam | 50 mg/kg (ampicillin dose) | 3 g |
| Vancomycin | 15 mg/kg | 15 mg/kg |

Many pediatric and adult hospitals are implementing ERAS protocols to facilitate a faster return to baseline for patients after surgical procedures. The general tenets of adult ERAS protocols include preoperative counseling, limited perioperative fasting, early postoperative oral intake and mobilization, “scheduled” pre- and postoperative opioid-sparing analgesia, regional analgesia, minimally invasive surgery (MIS), goal-directed use of intravenous (IV) fluids, and limited use of surgical drains and tubes. These tenets can also be applied to the pediatric and adolescent gynecology population.

Preoperatively, patients and family members both should be educated about expected postoperative pain, developmentally appropriate assessment of the severity of pain, and appropriate treatment and management options. Multimodal analgesia, using a variety of analgesic medications and techniques (including nerve blocks) combined with nonpharmacological interventions, should be used to manage postoperative pain in children and adolescents. Oral narcotics are preferred over IV medication, and intramuscular narcotics should be avoided. If IV narcotics are used, patient-controlled analgesia (PCA) is preferred. Administration of nonsteroidal anti-inflammatory drugs (NSAIDs), gabapentin, and acetaminophen, in the absence of any contraindication, is emphasized in the multimodal approach in addition to surgical site–specific wound infiltration with a long-acting, local anesthetic for postoperative pain management. Smith et al. demonstrated successful implementation of an ERAS protocol for pediatric and adolescent gynecology patients undergoing both laparoscopy and laparotomy. All patients were satisfied with their postoperative pain control, and 95% of patients were discharged requiring only non-narcotic medications.

# EXAMINATION UNDER ANESTHESIA AND VAGINOSCOPY

Vulvovaginitis is the most common reason a prepubertal girl presents to a gynecologist for evaluation. Examination of the perineum, hymen, and distal vagina can typically be accomplished in the office with patience, parental support, correct positioning, and distraction. Additionally, it is feasible to do vaginal swabs and/or vaginal irrigation during this exam.

Some symptoms or conditions, however, require a more complete assessment of the entire lower genital tract, including the proximal vagina and cervix. The most common indications requiring assessment of the entire lower genital tract include bleeding, trauma distal to the hymen, suspicion of the presence of a foreign object, and persistent vaginal discharge. Additional indications include

congenital conditions such as müllerian anomalies, disorders of sexual development (DSD), vaginal septi, persistent urogenital sinus, cloacal malformations, and evaluation after reconstruction (**TABLE 43.3**). A complete lower genital tract examination in the prepubertal or young adolescent patient is most effectively and least traumatically performed during an examination under anesthesia (EUA) with vaginoscopy.

## TABLE 43.3
## Indications for Evaluation of Upper Vagina and Cervix by Vaginoscopy

1. Vaginal bleeding
2. Persistent vaginal discharge
3. Suspected foreign object
4. Trauma beyond the hymen
5. Congenital condition (urogenital sinus, cloacal malformation, DSD, müllerian anomalies, vaginal septum)
6. Follow-up after reconstruction

EUA with vaginoscopy is a safe and effective method for examining the entire lower tract in infants, girls, and teens who require anesthesia for a complete examination. EUA with vaginoscopy is performed in a procedure or OR with sedation or general anesthesia with support of an anesthesiologist. All gynecologists have the skills and equipment to perform this procedure. Vaginoscopy requires minimal equipment: a scope (hysteroscope and/or pediatric cystoscope) with camera (or eye piece), a light source, and normal saline. Grasping forceps to retrieve identified foreign object and vaginal swabs to collect specimens should be readily available as well (**FIG. 43.1**).

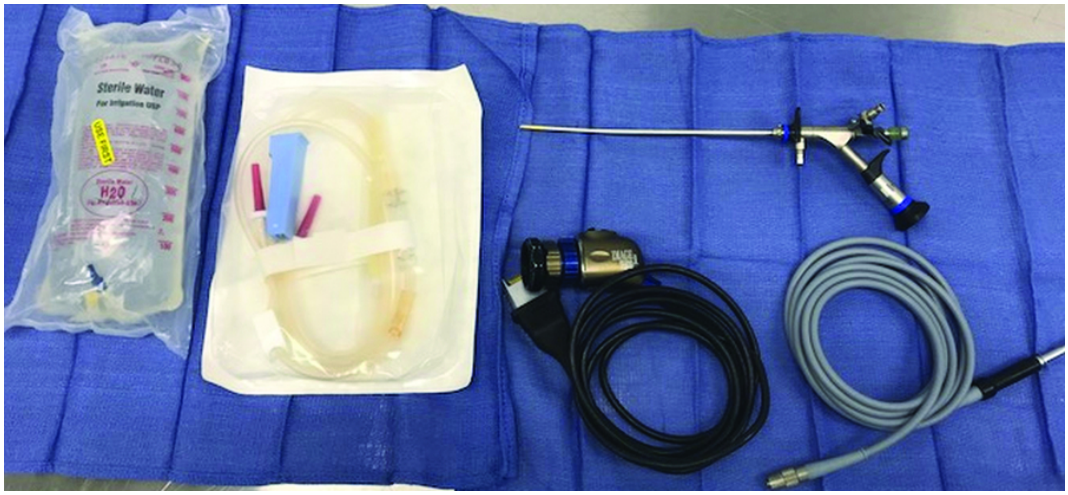



**FIGURE 43.1** Vaginoscopy equipment (left to right): saline, tubing, camera, scope, light source (Courtesy of Geri D. Hewitt, Chief, Department of Obstetrics and Gynecology, General Division Obstetrics and Gynecology, Nationwide Children's Hospital, Columbus, Ohio.)

After an appropriate level of anesthesia is obtained, a careful inspection of the external genitalia should be performed, by grasping the labia majora and gently lifting them up and out to inspect the clitoris, urethra, hymen, and lower vagina. The vaginoscope is then placed into the introitus carefully, avoiding trauma to the hymen. With one hand holding the vaginoscope, the other hand should carefully compress the vulvar tissue around the scope while saline is introduced into the vagina. The vaginoscope is then advanced under visualization, while the vagina fills and expands with saline. The entire vagina and cervix can be examined (**FIG. 43.2**). In prepubertal patients, it is important to direct the vaginoscope posteriorly to see the cervix, which is often flush with the vagina. Graspers can be used to remove foreign objects, the vagina can be irrigated, and after completion of the vaginoscopy, vaginal swabs can be collected. Delaying collection of vaginal swabs until after completion of the

vaginoscopy avoids visualizing iatrogenic bleeding and/or abrasions during the procedure (**BOX 43.1**).

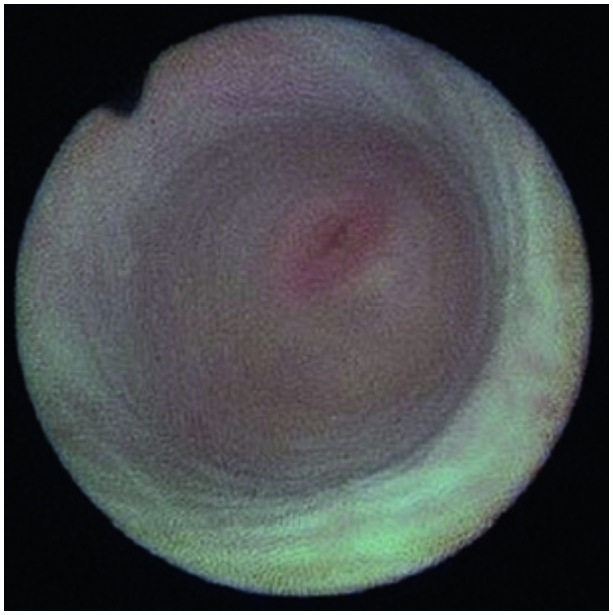


**FIGURE 43.2** Entire vagina and normal cervix seen during vaginoscopy. (Courtesy of Geri D. Hewitt, Chief, Department of Obstetrics and Gynecology, General Division Obstetrics and Gynecology, Nationwide Children's Hospital, Columbus, Ohio.)

## BOX 43.1 STEPS IN THE PROCEDURE

### Examination Under Anesthesia With Vaginoscopy

- Exam of external genitalia.
- Place vaginoscope; be careful to avoid trauma to hymen.
- Compress vulvar tissue around vaginoscope.

- Fill vagina with saline to expand vagina.
- Advance vaginoscope to visualize entire vagina and cervix.
- Collect specimens.

## MANAGEMENT OF HYMENAL VARIANTS

There is a wide range of normal hymenal configurations including annular, crescentic, and fimbriated/redundant hymens. Failure of the hymenal tissue to perforate completely during the perinatal period can result in a range of hymenal variants such as imperforate, microperforate, or septate, which often require corrective surgical intervention. Hymenal variants can limit menstrual egress as well as tampon use or comfortable penetrative vaginal sexual activity (**FIG. 43.3**).

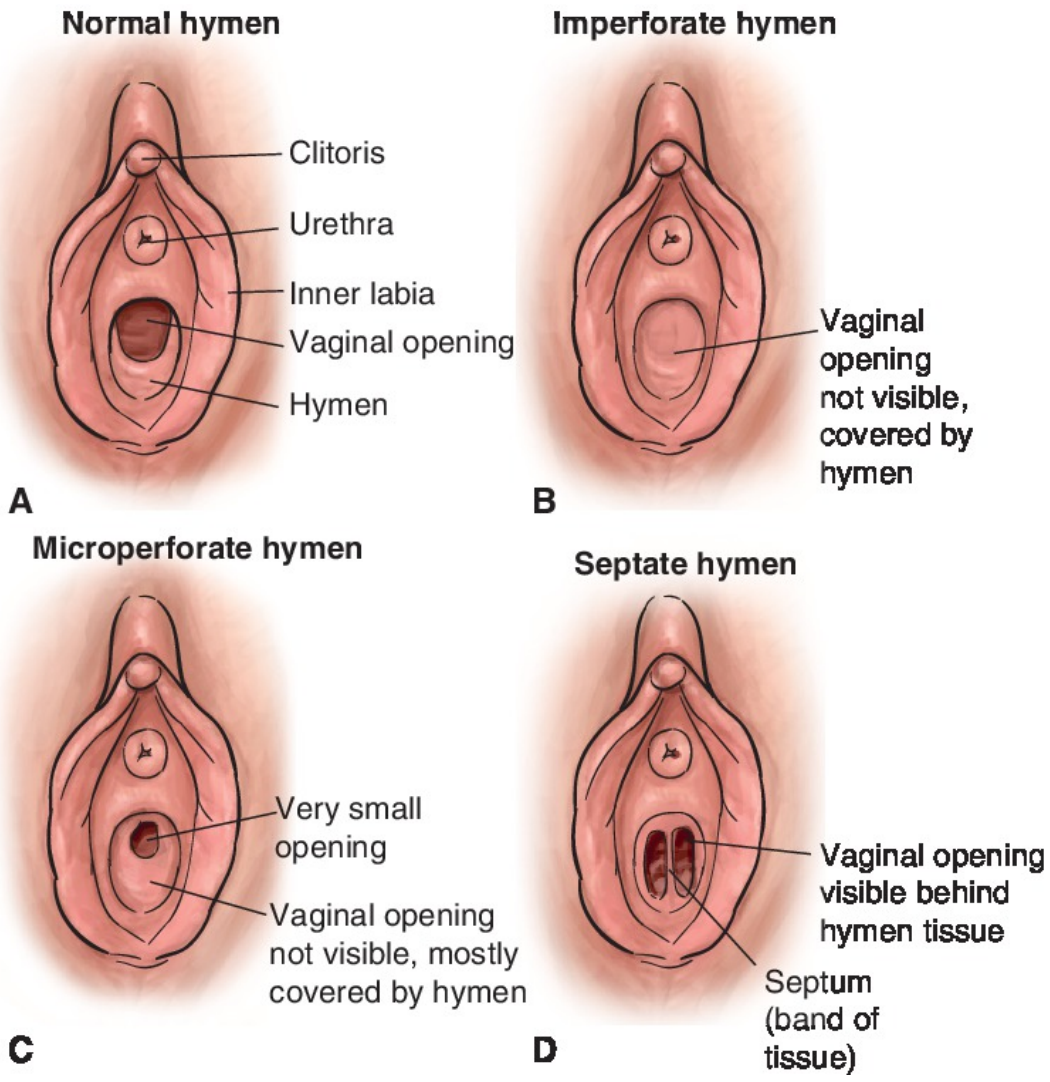



**FIGURE 43.3** A-D. Hymenal variants.

Imperforate hymen is the most common vaginal obstructive anomaly with an estimated incidence of 1 in 1000 to 1 in 10 000. Imperforate hymen may present in the newborn period with a hymenal bulge secondary to mucocolpos resulting from maternal estrogen effect. Typically, neonatal mucocolpos will resolve within 1-2 weeks and no intervention is required. Surgical repair should be delayed until well after thelarche, the onset of breast development, since estrogen production is increased during this time and will facilitate healing. Neonatal mucocolpos secondary to the imperforate hymen causing urinary retention and/or hydronephrosis is the rare indication for

earlier intervention. Aspiration of vaginal mucous or blood through an imperforate hymen should be avoided due to risk of causing ascending infection.

Definitive surgical correction (hymenectomy) for imperforate hymen should be performed after thelarche but ideally before the patient experiences menarche. Menarche with the inability for menstrual egress results in hematocolpos and possibly hematometra. Patients often experience cyclic pelvic pain. If enough menstrual blood accumulates, constipation or urinary retention may occur. If left uncorrected, retrograde menstruation may cause endometriosis and adhesive disease. Imperforate hymen can often be diagnosed with a careful perineal examination (**FIG. 43.4**). Preoperative evaluation should include pelvic ultrasound to confirm the correct diagnosis and rule out other more complex types of lower genital tract obstruction.

**FIGURE 43.4** Complete imperforate hymen with bulging hymenal membrane. (Courtesy of North American Society of Pediatric and Adolescent Gynecology CDROM.)

Hymenectomy for imperforate hymen should be performed in a procedure room or operating room (OR) with general anesthesia, although regional anesthesia or sedation could be considered. The patient should be placed in high dorsal lithotomy position, and after perineal prep, a Foley catheter is placed to identify the urethra and decrease the likelihood of injury. If a bulging hymenal membrane is not readily visible, placing a hand transabdominally on the uterine

fundus and applying pressure facilitates identification of the hymen. Stay sutures can be placed on the hymenal tissue on either side of a proposed incision site for traction. The incision into the hymenal tissue can be performed with electrocautery or sharp dissection. If menarche has occurred, there are frequently copious amounts of menstrual blood, which often clogs the suction device, so having more than one suction device available is helpful. Once the hymen has been transected and the vagina entered, the hymenal tissue should be excised so an adequate vaginal opening (admits at least one digit easily) is created. While descriptions of cruciate or stellate incisions in the hymen to relieve the obstruction have been described, most authors suggest removal of the hymenal tissue since spontaneous reformation of imperforation has been reported. The hymenal ring is then sutured with interrupted 4-0 absorbable suture to achieve hemostasis and prevent scarring. A local anesthetic can be applied or injected in the area to decrease postoperative pain. Preoperative aspiration and/or drainage should be avoided to decrease likelihood of an ascending infection, particularly in the presence of hematometra. Microperforate and cribriform hymenal variants should be repaired in a similar manner (**BOX 43.2**).

## BOX 43.2 STEPS IN THE PROCEDURE

### Hymenectomy

- If hymen is imperforate, perform preoperative ultrasound to confirm anatomy.
- Catheterize urethra to decrease the risk of injury.
- Excise excessive hymenal tissue.
- Obtain hemostasis with interrupted stitches of absorbable suture.
- Local anesthesia applied or injected for pain relief.
- Remove catheter.

Septate hymenal variants can sometimes be corrected in the office with local anesthesia in a mature, cooperative adolescent (**FIG. 43.5**). Placing a Q-tip behind the band confirms a septate hymenal variant and distinguishes it from a longitudinal vaginal septum. Leaving the Q-tip in place during the procedure can be very helpful for exposure. After infiltration with 1% lidocaine, the lower and upper edge of the hymenal band should be sutured using absorbable suture and the excess hymen can be excised sharply with scissors or a scalpel. If necessary, silver nitrate can be used for additional hemostasis.

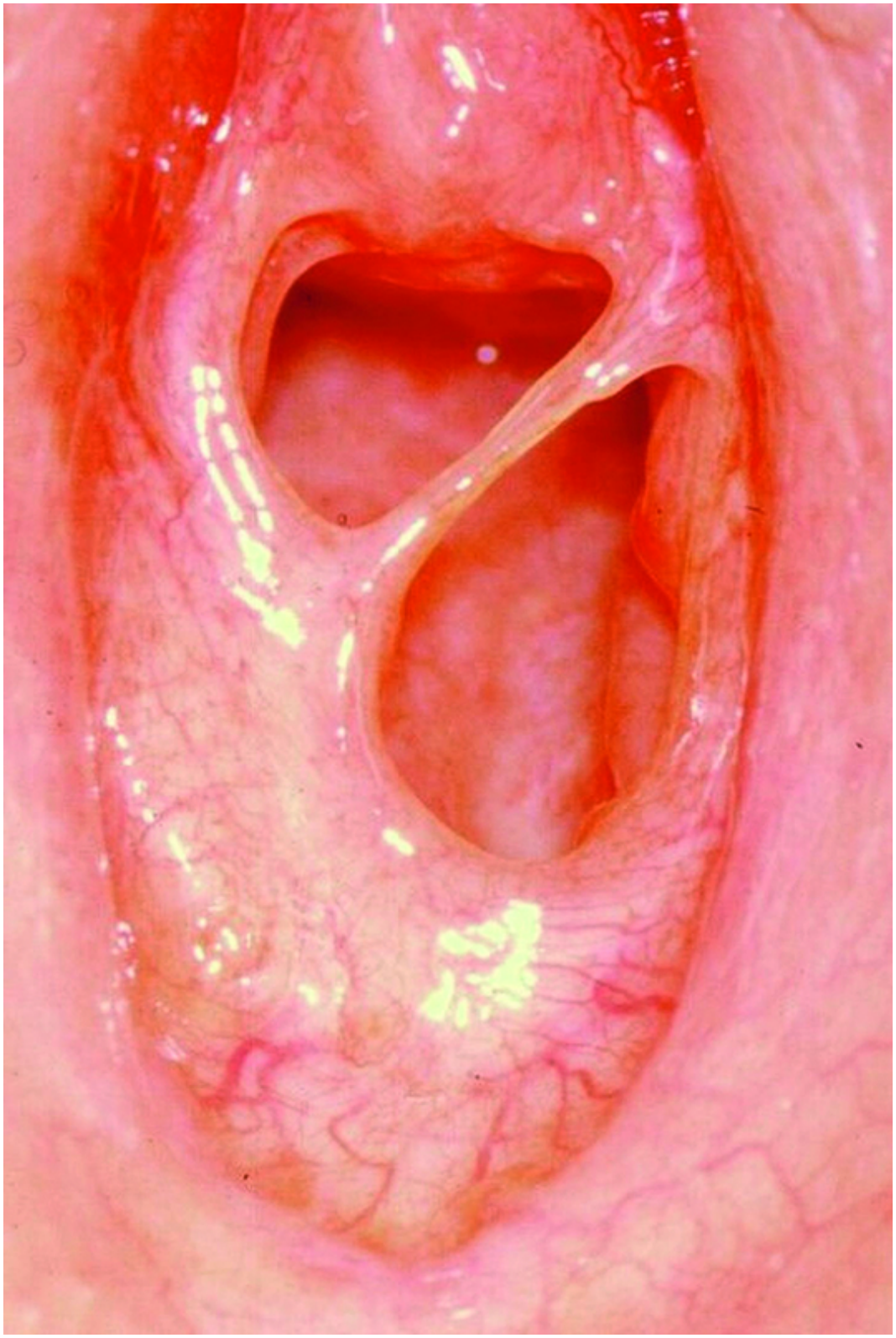


**FIGURE 43.5** Septate hymenal variant. (Courtesy of North American Society of Pediatric and Adolescent Gynecology CDROM.)

## MANAGEMENT OF GENITAL INJURIES

Pediatric genital injuries represent <1% of overall pediatric injuries. Genital injuries are more common and less severe in girls as compared to boys. Injuries may be accidental or nonaccidental. Accidental genital injuries in girls and adolescents include straddle injuries (the most common type), falls, motor vehicle accidents, animal bites, burns from batteries or other caustic agents, pelvic fractures, injuries from inline skating and other "splits" accidents. Vaginal insufflation injuries associated with high-pressure water entering the vagina as in jet ski and water park accidents can also occur. Nonaccidental injuries include those related to sexual abuse, consensual sexual activity, and female genital mutilation. The external genitalia and unestrogenized mucosa of prepubertal girls are highly vascularized, and even relatively minor injuries can bleed profusely.

Evaluation of a patient presenting with genital trauma begins with assessment of vital signs, airway, breathing, circulation and evaluation of the sites, and sources of trauma. A careful history is performed to assess the possibility of abuse and extent of the injury. Corroboration by an eye witness, if available, is important. The medical provider should always assess whether the history is consistent with clinical findings. The history as given by the child or adolescent is the most important factor to determine the etiology of genital injuries as abuse or accidental (**TABLE 43.4**).

## TABLE 43.4
## Accidental vs Nonaccidental Genital Injury

| ACCIDENTAL | NONACCIDENTAL |
|---|---|
| History given by patient compatible with injury | History given by patient not compatible with injury |
| Reliable witness supports history | Event unwitnessed<br>Delay in seeking care |

The severity of the injury and amount of bleeding determines how and where to examine the patient. The majority of genital injuries in girls and adolescent females are minor and can be examined in the office or emergency department (ED) setting. If the patient cannot tolerate an exam in the ED, light conscious sedation can be administered. However, most experts agree that general anesthesia in an OR is the best way to completely assess the full extent of a genital injury and should be considered if there is significant vaginal bleeding, hymenal trauma, any concern of penetrating vaginal injury, or inability to assess the full extent of the injury (eg, large vulvar hematoma or extensive laceration). During EUA, vaginoscopy enables visualization of the entire lower genital tract.

Since most genital injuries are minor, many can be managed conservatively without surgical intervention. Prerequisites for conservative management are the ability to void spontaneously, minimal bleeding, and successful examination of the extent of the injury. Nonhymenal genital injuries resulting in abrasions, ecchymosis, edema, hematomas, petechial, blood blisters, and superficial lacerations all resolve spontaneously in a few days to a couple of weeks, typically without any scarring, permanent changes, or damage. Conservative management includes using sitz baths, application of inert barriers, emollients, or topical antibiotics and reduced physical activity for 48-72 hours.

Extensive genital injuries will require surgical repair to control bleeding, restore function and anatomy, and prevent infection or

tissue necrosis. Management is dictated by the type and extent of the injury. Debridement of devitalized tissue and wound irrigation with saline and antiseptic solutions should be performed. If no infection is present, wounds can be safely sutured and closed primarily.

Indications for delayed wound closure include deep stab or puncture wounds, contaminated wounds, small noncosmetic animal bites, abscess cavities, and delayed presentation (more than 18 hours after occurrence). When planning delayed closure, the area is cleaned and debrided of foreign material. Following the 4- to 5-day waiting period if clean granulation tissue is present, the wound may be closed. Lacerations should be subsequently closed, in layers if needed, with absorbable suture.

Very large or expanding hematomas may require evacuation to decrease the chance of tissue necrosis from pressure or secondary infection. When incising large vulvar hematomas, one should incise along the medial mucosal surface near the vaginal orifice. After opening the hematoma, the bed is debrided of clot and devascularized tissue, hemostasis is obtained, a closed system drain is placed exiting the skin in a dependent position, and then the skin is closed primarily. The drain prevents reaccumulation of blood, reduces pain, reduces the risk of bacterial growth, and can be removed after 24 hours in most cases.

If the genital injury is severe, other organ systems may be involved. Urinary catheterization or cystoscopy is indicated when urologic injury is suspected based on the location, type, or extent of injury. Pelvic fracture with hematuria should raise suspicion for urologic injury. Penetrating injuries may involve the perineal body, anus, rectum, or anal sphincter muscle complex and may necessitate rectal examination or proctoscopy. Significant anorectal involvement may require fecal diversion as well as repair. Any penetrating vaginal injury can extend into the peritoneal cavity causing visceral injury and require pelvic imaging or laparoscopy to fully determine the extent of injury (**BOX 43.3**).

## BOX 43.3 STEPS IN THE PROCEDURE

## Management of Genital Injury

- Stabilize the patient.
- Obtain history to determine if compatible with injury.
- Examine to assess extent of injury.
- If not amenable to conservative measures, surgical repair.
- Consult with urology, surgery, and/or orthopedic services indicated.
- Follow-up examination to assess healing.

Patients who experience genital injury warrant follow-up to document healing. The repair of genital injury may be associated with complications such as wound infection, dehiscence, and fistulas. Many authors suggest using topical estrogen creams postoperatively to promote tissue healing. Timing and extent of exam performed at follow-up should be individualized depending on the extent of the injury and repair, ranging from an office examination in 3 or 4 days or another EUA with vaginoscopy weeks or months later.

# LAPAROSCOPY IN THE PEDIATRIC AND ADOLESCENT PATIENT

Laparoscopy has become the standard surgical approach for many pediatric and adolescent gynecologic conditions such as endometriosis, benign adnexal masses, suspected adnexal torsion, and some müllerian anomalies. The advantages of laparoscopic surgery include better cosmesis, improved visualization, reduced postoperative pain, and shorter hospital stays.

While many adolescent patients are adult sized, there are several technical considerations when performing laparoscopy on smaller adolescent or pediatric patients including patient positioning, route of peritoneal access, intra-abdominal pressure tolerance, placement of incision sites, and selection of port and instrument

sizes (**FIG. 43.6**). Positioning adolescent patients should mirror that of adult patients, with access to the vagina for uterine manipulation. Uterine manipulation can be accomplished with a digit in the posterior vaginal fourchette or with a small cervical dilator attached to a single-tooth tenaculum placed on the anterior lip of the cervix. Patients who are large enough should be placed in dorsal lithotomy position with their legs in Allen stirrups; if patients are too small for such positioning, they can be placed supine in frog-leg position for vaginal access. Tucking the arms (with thumb pointing anterior to avoid median nerve damage) offers the advantage of more room for the surgeon. A vaginal prep with care to avoid trauma is accomplished with prep solution applied with a sponge stick or via a filled Toomey syringe. If the patient is unable to void prior to the procedure or the case exceeds 2 hours duration, a Foley catheter should be placed to deflate the bladder and allow complete visualization of the pelvis. ERAS protocols encourage catheter removal prior to leaving the OR.

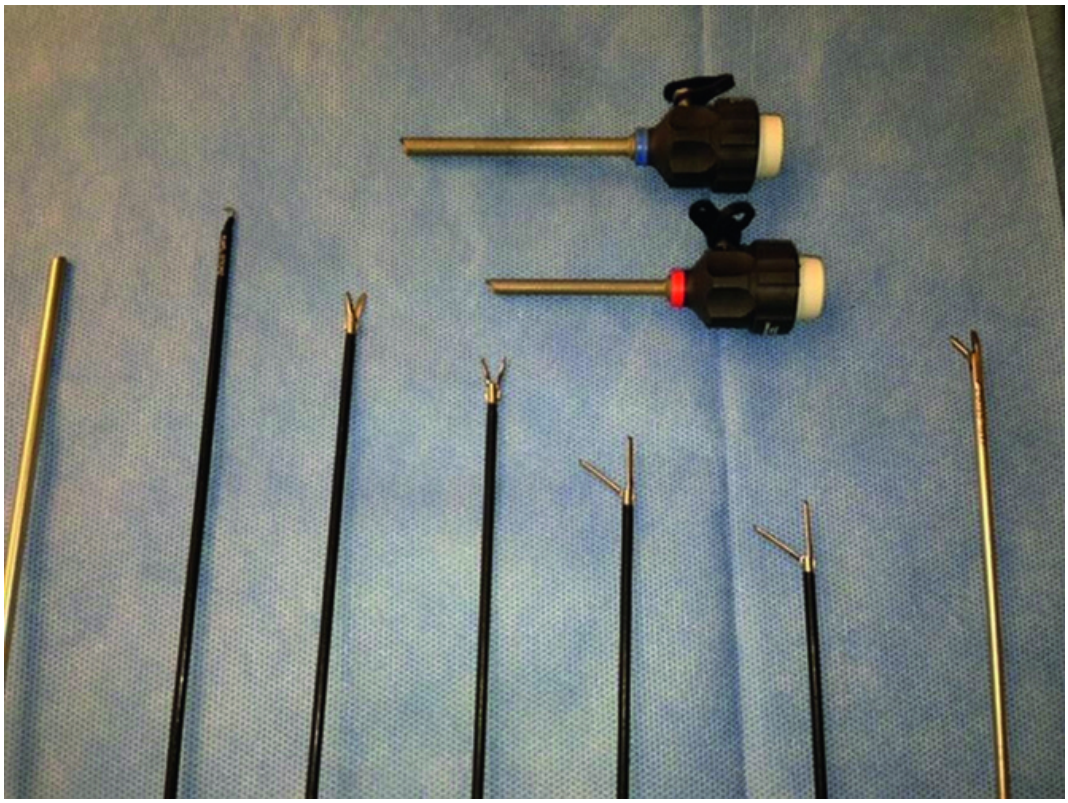


**FIGURE 43.6** Pediatric laparoscopy equipment. 2-, 3-, and 5-mm instruments are available. (Courtesy of Karen Diefenbach, MD. Nationwide Children's Hospital, Columbus, Ohio.)

Similar to the adult patient, peritoneal access can be achieved by a wide range of methods including Veress needle, direct trocar, direct visual using a Visiport or Optiview trocar, or open entry. Because it is the thinnest portion of the abdominal wall, entry through the midpoint of the umbilicus is generally recommended. Since there is no evidence in the literature directly comparing complication rates among the various entry methods in pediatric patients, individual surgeon's experience and preference dictate the method chosen. A Cochrane review (performed in only adult patients) showed no difference in entry-related complication rates across various methods. Pediatric patients are often thin, with a significantly smaller distance between umbilicus and pelvic brim. Care and understanding of these anatomic differences is key in avoiding entry-related injuries to large vessels or the bowel.

Insufflation in the pediatric age group is based on the size and age of the patient, body habitus, and abdominal wall compliance. The pediatric abdominal wall is less resistant and more compliant compared to adults, making trocar placement more difficult and increasing the risk for injury to other intra-abdominal structures. Insufflation rates should start at low flow to avoid vagal response and then increase only as much as needed to overcome loss from leak or suction. Average flow rates in infants should be 1 L/min and in all others 1-2 L/min. Recommended intra-abdominal pressures are 8-10 mm Hg in infants (0-2 years), 10-12 mm Hg in children (2-10 years), and 15 mm Hg in adolescents (>10 years) (**TABLE 43.5**).

## TABLE 43.5
## Recommendations for Intra-abdominal Pressure

## During Laparoscopy Based on Age

| AGE (y) | mm Hg |
|---|---|
| 0-2 | 8-10 |
| 2-10 | 10-12 |
| >10 | 15 |

Lateral, accessory ports should be placed under direct visualization and higher on the abdominal wall than what would be typical in adult patients to allow for a more ergonomic approach to the pelvis and decrease the likelihood of injuring the bladder (**FIG. 43.7**). Surgeons should use the smallest ports necessary to complete their intended procedure. There are currently 2-, 3-, 5-, and 10-mm ports available. While specimen entrapment sacs often require 5-mm ports, many instruments like dissectors, scissors, grasping retractors, and bipolar instrumentation are available in 2-, 3-, and 5-mm sizes. Optic sizes vary and there is no significant loss of optical quality with the use of a smaller 4- and 5-mm lens.

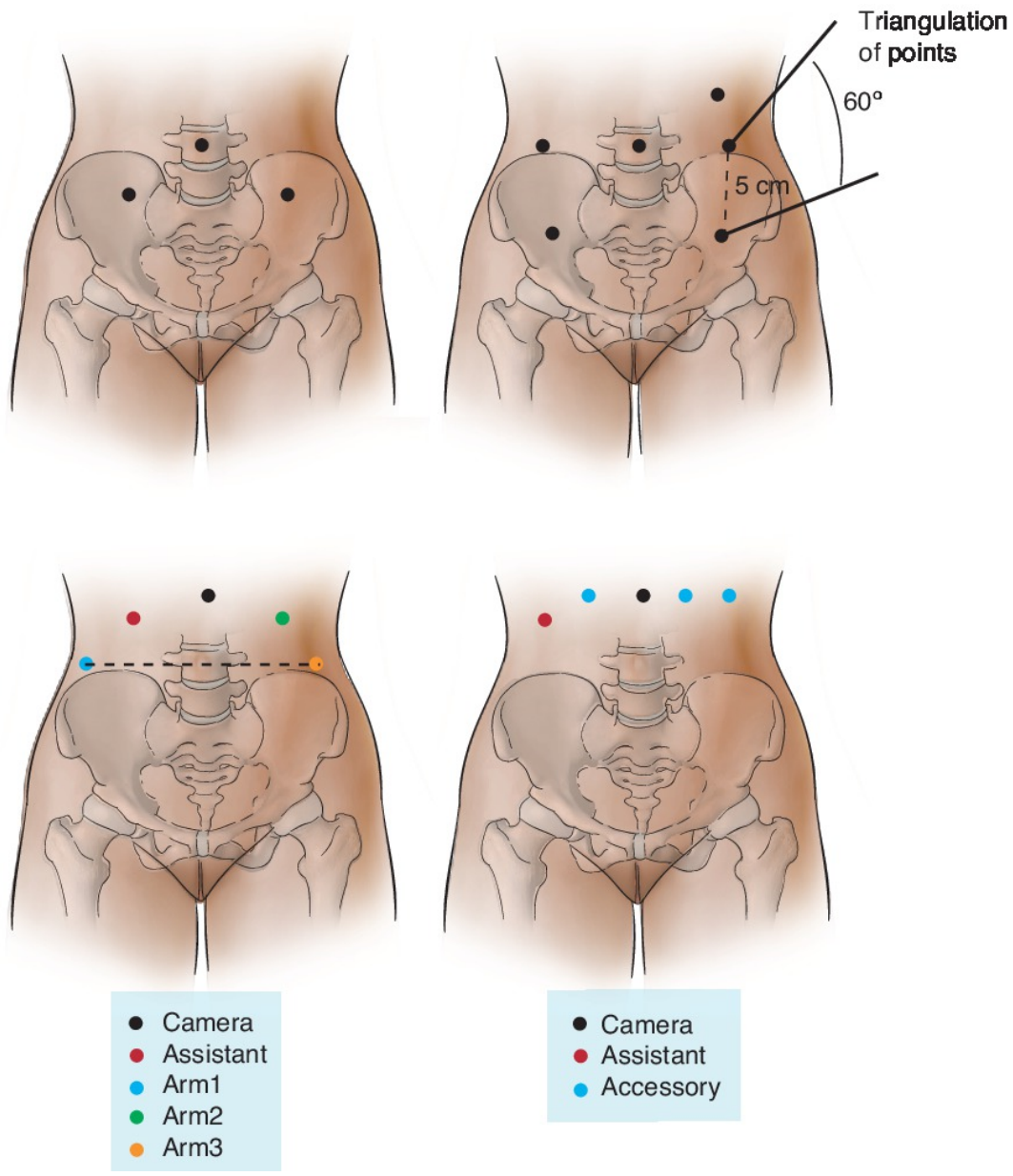



**FIGURE 43.7** Laparoscopic port placement in pediatric patients.

Single-incision laparoscopic surgery has been used successfully for the treatment of adnexal pathology; patients have successfully undergone cystectomy, salpingo-oophorectomy, ovarian detorsion, adnexal biopsy, and oophoropexy using this approach. Single-incision laparoscopic surgery uses a single umbilical incision, with

three trocars placed through this incision in a triangular fashion. The theoretical advantages of single-incision laparoscopic surgery are lower number of trocar incisions, decreased risk of trocar entry injury to bowel or vascular structures, and improved cosmesis. A potential drawback of this method is crossing of the instruments when working in the pelvis. More experience is needed to determine whether single-incision laparoscopic surgery offers distinct advantages over traditional laparoscopic surgery for pediatric and adolescent gynecologic conditions.

# ADNEXAL SURGERY

Adnexal pathology in girls and young women occur due to a wide range of etiologies including both benign and malignant conditions of the ovary and/or fallopian tube. Patients may present with symptoms ranging from acute and severe pain with adnexal torsion to being completely asymptomatic when adnexal masses are found incidentally during physical examination or imaging for unrelated conditions. The vast majority of adnexal masses identified in girls and young women are benign. In patients diagnosed with ovarian neoplasms, only 10%-20% are malignant. Given the prevalence of benign conditions and young age of the patients, surgical interventions should prioritize preservation of ovarian and tubal function when clinically appropriate.

## Preoperative Risk Stratification of Ovarian Masses

Significant variability exists regarding the management of ovarian neoplasms in girl and young women. Berger-Chen et al. reported that 40% of girls under age 18 years with benign ovarian disease were treated with an oophorectomy. In their series, girls with benign ovarian disease who were over 12 years of age and treated by a gynecologist were more likely to undergo ovarian cystectomy as opposed to oophorectomy. Bergeron et al. reported that gynecologists were significantly more likely to perform ovarian

cystectomy (80%) compared to other surgeons (68%) in cases of benign ovarian disease patients under age 21 years. Gonzalez et al. identified several risk factors for oophorectomy as treatment for benign ovarian neoplasms including lack of gynecologist on staff, surgery performed by a pediatric surgeon as opposed to a gynecologist, and direct admission from the ED. Gynecologists play an important role in advocating for ovarian preservation in patients requiring surgical intervention for adnexal masses.

Many authors have described algorithms and reported on their experiences in using preoperative risk stratification with radiologic imaging and serum tumor markers in girls and young women presenting with larger or complex adnexal masses. Radiologic risk factors associated with malignancy include larger tumor size, complexity, and presence of thick septations, solid components, or papillations (**TABLE 43.6**). Lawrence et al. recommended using a panel of tumor markers when an ovarian malignancy is suspected as no single tumor marker provided enough reliability **(TABLE 43.7)**. Aldrink et al. reported that implementation of a multidisciplinary algorithm safely decreased the likelihood of performing oophorectomy for benign ovarian disease while appropriately treating ovarian malignancies.

## TABLE 43.6
## Findings on Imaging Suggestive of an Ovarian Malignancy

| |
|---|
| Ovarian mass >8 cm |
| Presence of free abdominal fluid |
| Solid components |
| Papillary projections |
| Ill-defined borders |
| Complex components |
| Extension into surrounding structures |
| Lymphadenopathy |
| Metastatic disease |

## TABLE 43.7
## Recommended Tumor Marker Panel for Suspected Ovarian Malignancies Based on Imaging

| |
|---|
| AFP |
| Beta-hCG |
| LDH |
| CA 125 |
| Inhibin A |
| Inhibin B |

Increased emphasis on preoperative risk stratification and ovarian sparing surgery for ovarian neoplasms at low risk of malignancy has led to fewer oophorectomies for benign disease in pediatric and adolescent patients. Patients deemed at high risk of malignancy should undergo surgical staging with oophorectomy as directed by Children's Oncology Group guidelines. Preoperatively assessing the risk of malignancy is critical in determining the appropriate surgical procedure.

# Ovarian Cystectomy

In the absence of an acute surgical emergency, such as suspected adnexal torsion or hemoperitoneum, patients with an ovarian mass should complete preoperative risk stratification with imaging and tumor markers when imaging raises concerns for malignancy. If preoperative risk stratification suggests a low risk of malignancy, ovarian cystectomy is the preferred surgical intervention.

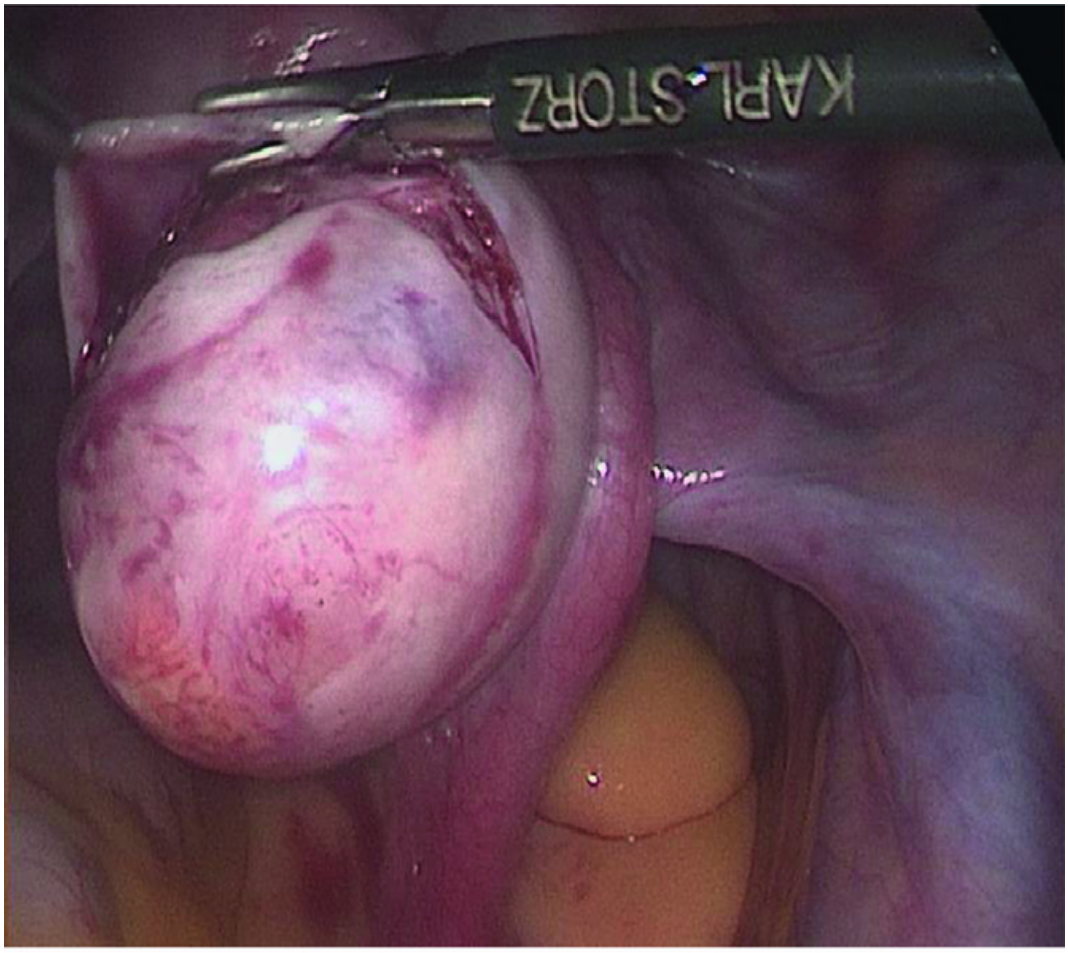
The surgical approach depends on size of mass, patient body habitus, and operator preference and experience. Several authors report success with laparoscopic ovarian cystectomy for benign ovarian disease. One argument against a laparoscopic approach for ovarian cystectomy has been concern for intraoperative cyst rupture with ensuing complications such as chemical peritonitis, recurrence,

upstaging of malignant tumors, adhesion formation, or infertility. Yousef et al. followed patients after surgery for both benign and malignant ovarian disease and found no difference in recurrence rates when comparing patients with and without intraoperative cyst rupture. Childress et al. described their series on 144 patients treated with cystectomy for benign cystic teratomas. Most patients (106/144) underwent laparoscopy, and the majority of those cases had intraoperative spillage of cyst contents with few reported postoperative complications. While laparoscopy and tumor size >5 cm were risk factors for intraoperative cyst rupture, there was no difference in recurrence rates or reoperation between the group treated laparoscopically compared to the group treated with laparotomy.

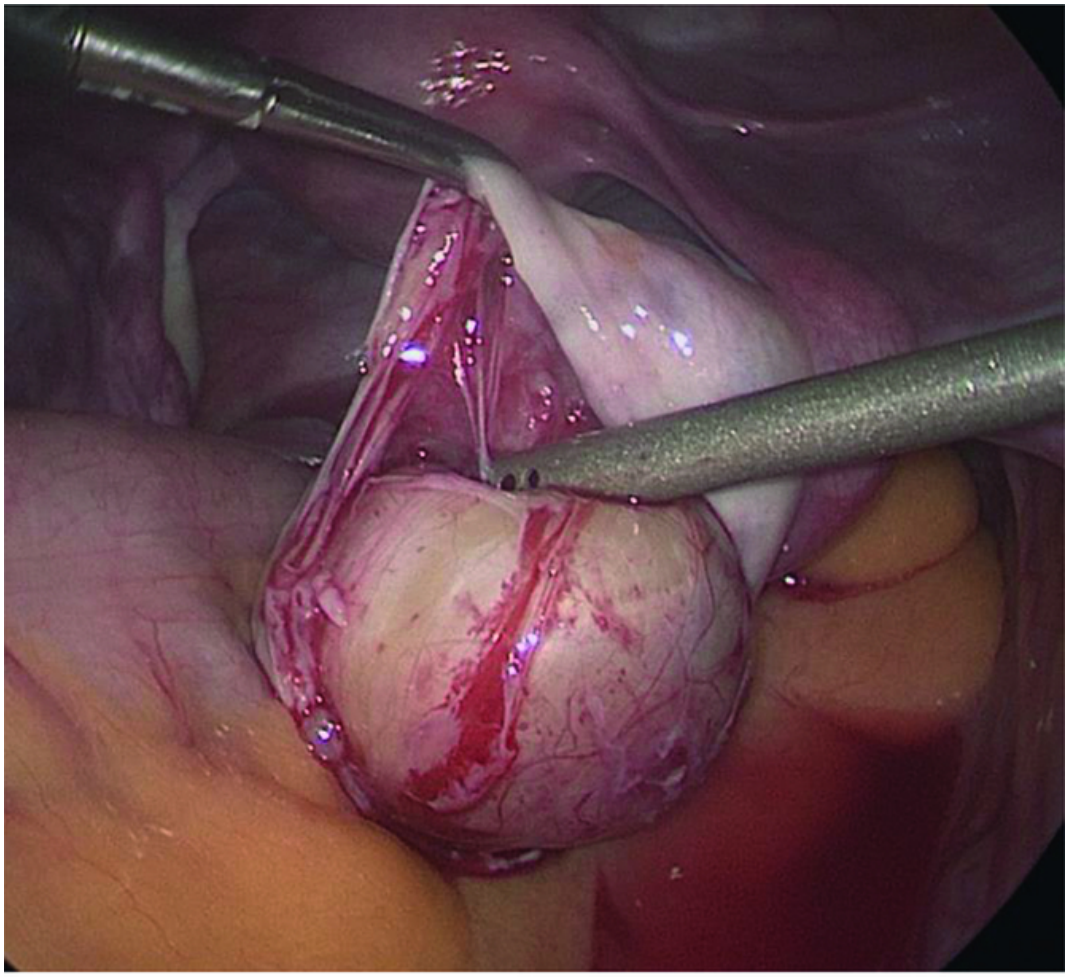
Larger masses can be managed successfully with minilaparotomy and decompression of the mass prior to cystectomy. Trotman et al. compared 44 patients undergoing minilaparotomy or laparoscopy for benign adnexal lesions and showed no difference in postoperative recovery time. The median cyst size was 15.5 cm in the minilaparotomy group and 6.0 cm in the laparoscopy group.

Regardless of surgical approach, the technique for performing an ovarian cystectomy is similar to performing fertility-preserving cystectomy in the adult patient. The goal of the procedure is to separate and remove the entire cyst from the overlying ovarian tissue. An incision is made in the ovarian tissue, either sharply or with electrocautery, below the equatorial plane of the cyst and closer to the normal portion of the ovary, usually near the hilum. Ideally, this incision should not enter the cyst cavity (**FIG. 43.8A**). Once the plane between the ovary and the underlying cyst is identified, hydrodissection (with the laparoscopic irrigator/aspirator) is performed to further develop the tissue planes. Blunt and sharp dissection are used to separate the mass from the overlying ovarian tissue. Using atraumatic graspers, the overlying ovary is peeled from the underlying cyst using traction (**FIG. 43.8B and C**). For very large cysts with low risk of malignancy, the cyst can be purposefully ruptured and decompressed to facilitate separation and removal. Once the cyst has been entirely removed, the ovary needs to be examined to secure hemostasis. While hemostasis can be obtained

with suturing, electrocautery, or use of hemostatic agents, the remaining ovarian tissue does not need to be reapproximated or closed (**FIG. 43.8D**). There are limited data suggesting that ovarian cystectomy may have both short-term and long-term negative impact on ovarian reserve, as measured by antral follicle count and anti-müllerian hormone levels. To diminish potential negative impact on ovarian reserve, care should be taken in handling the ovary and electrocautery should be used sparingly (**BOX 43.4**).




**A**



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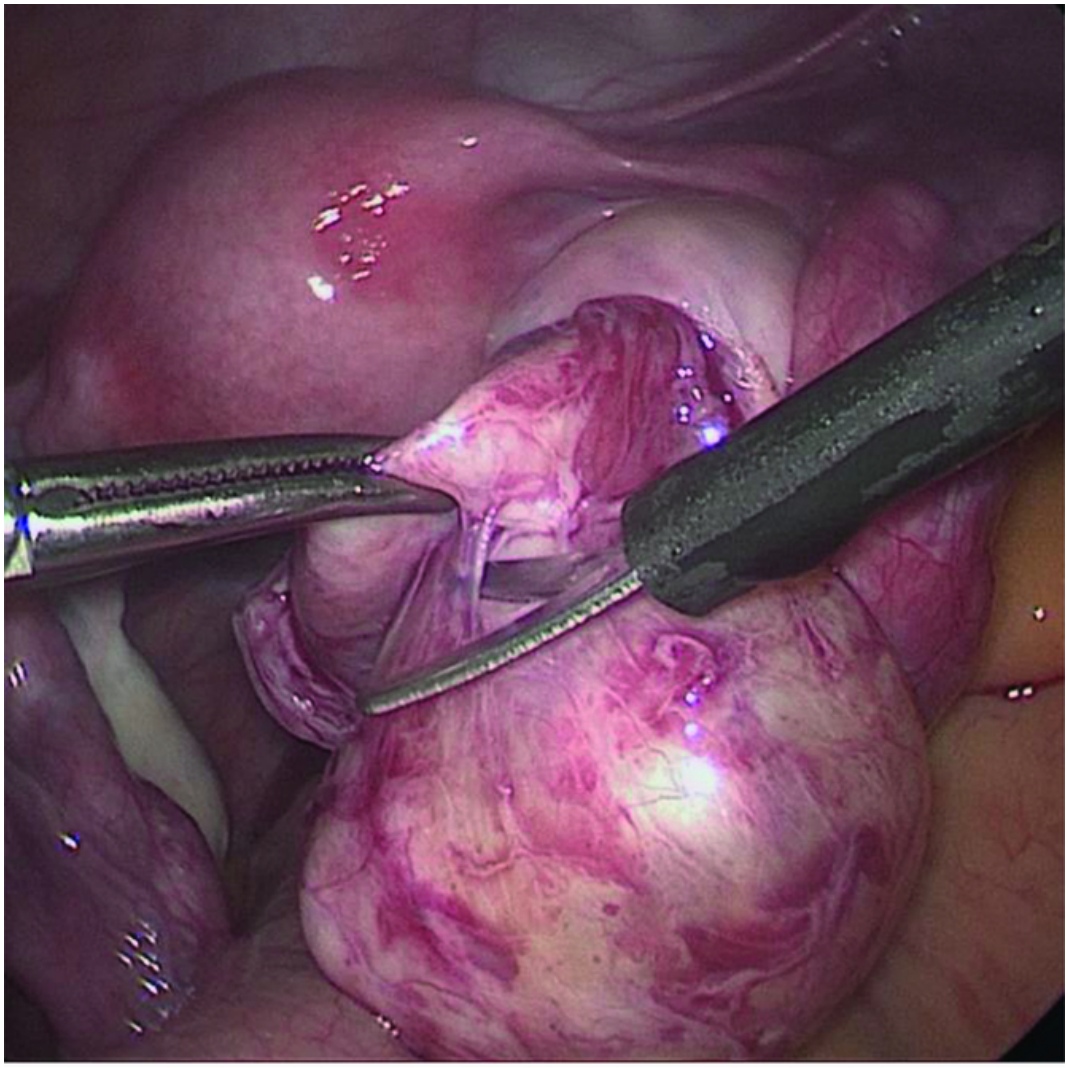

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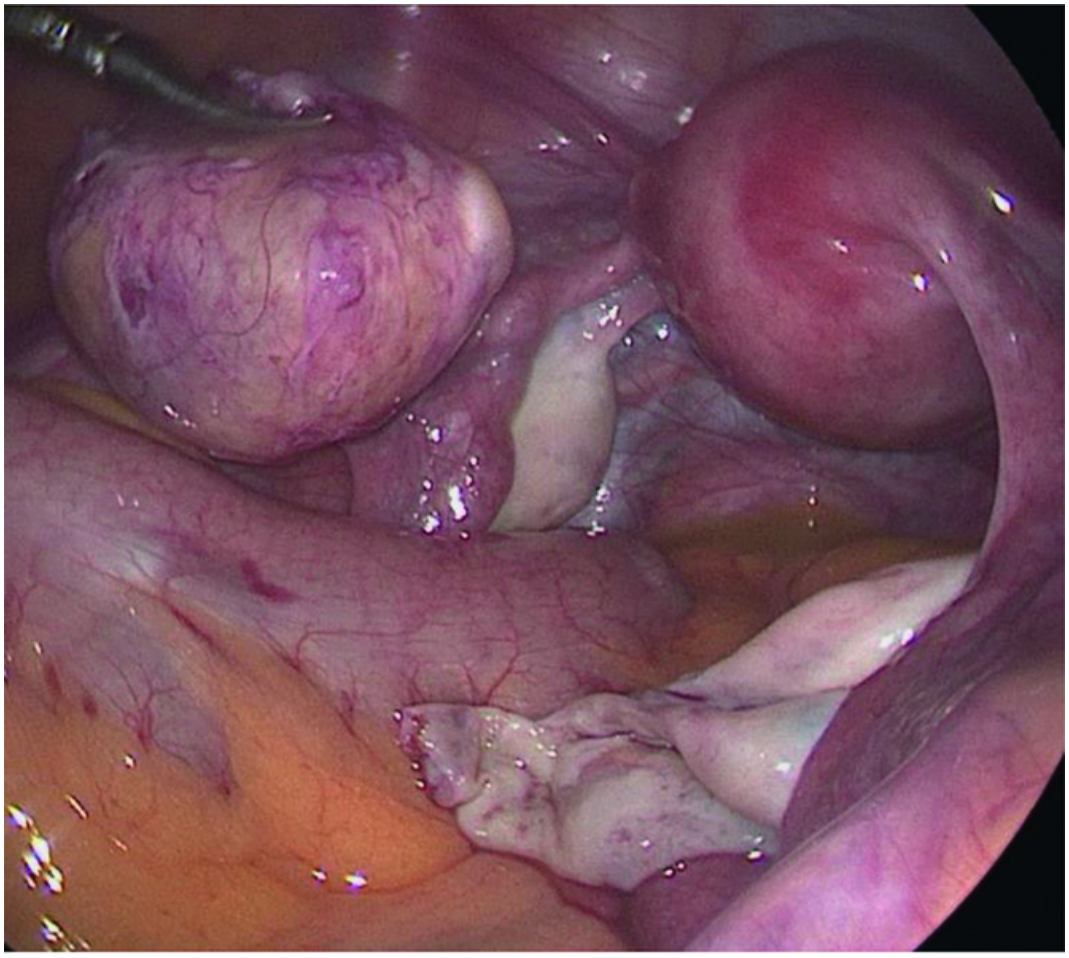


D

**FIGURE 43.8** **A.** Ovarian cystectomy. Ovarian incision is made without rupture of the underlying cyst and a plane is developed between the overlying ovarian tissue and ovarian cyst. **B.**Blunt dissection of overlying ovarian tissue and ovarian cyst. **C.**Sharp dissection of overlying ovarian tissue and ovarian cyst. **D.**Hemostatic ovarian tissue after removal of the ovarian cyst. (Courtesy of Kate McCracken, MD, Pediatric and

Adolescent Gynecology, Nationwide Children's Hospital, Columbus, Ohio.)

## BOX 43.4 STEPS IN THE PROCEDURE

### Ovarian Cystectomy

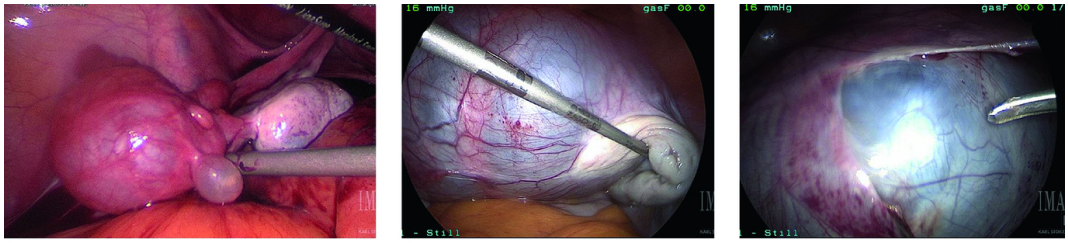
- Complete preoperative risk assessment.
- Determine surgical approach.
- Incise ovarian cortex overlying the mass.
- Develop plane between cyst and ovary. Can use hydro, blunt, and sharp dissection.
- Remove cyst.
- Secure hemostasis on ovarian tissue with electrocautery sparingly, hemostatic agents or suture.

Routine postoperative imaging is not necessary in patients undergoing surgery for benign ovarian neoplasm, despite the low risk of treatment failure with ovarian cystectomy or recurrence in the ipsilateral or contralateral ovary. Knaus et al. examined the use of postoperative pelvic ultrasound in the follow-up of over 400 patients who had undergone surgery for benign ovarian neoplasms. The authors determined that routine surveillance imaging offered no benefit but increased cost and burden to patients and their families. The authors suggested repeat pelvic ultrasound only for patients with symptoms or an identified mass on physical examination. All subsequent torsions or malignancies were identified when imaging symptomatic patients.

# Paratubal Cysts

Paratubal cysts (PTCs), also called paraovarian cysts, are remnants of the paramesonephric or mesonephric ducts and are associated

with obesity and hyperandrogenicity. PTCs arise in the broad ligament between the fallopian tube and ovary. PTCs are more commonly seen in adolescents and may be hormonally mediated. PTCs can vary in size from small (<1 cm) (**FIG. 43.9A**) to large (>8 cm) (**FIG. 43.9B**) and patients present with acute pain with torsion, a dull, aching pressure sensation due to mass effect, or they can be asymptomatic. Preoperative diagnosis can be difficult as Muolokwu et al. reported in their series only 30% of PTCs were identified preoperatively. Sonographically, PTCs appear as unilocular and anechoic or hypoechoic lesions. Preoperative differential diagnosis includes ovarian cyst, PTC, mesenteric cyst, and abdominal or pelvic lymphangioma. Pelvic MRI is helpful to clarify pelvic findings particularly if it identifies a homogeneous cystic mass near the ipsilateral round ligament or uterus and/or if normal ovaries can be seen distinctly separate from the mass. The incidence of actual neoplasm associated with PTCs is 2%-3% and includes cystadenocarcinoma, papillary carcinoma, and serous papillary neoplasms.



A B C

**FIGURE 43.9** **A.** Paratubal cyst. **B.** Large paratubal cyst next to normal ovary. **C.** Incision in the broad ligament and dissection of the underlying large paratubal cyst. (Courtesy of Geri D. Hewitt, Chief, Department of Obstetrics and Gynecology, General Division Obstetrics and Gynecology,

Nationwide Children's Hospital, Columbus, Ohio.)

The goal of surgical intervention is complete removal of the mass with preservation of tubal function. Depending on the size of the mass, both laparoscopy and minilaparotomy with decompression of the cyst are well-described surgical approaches. Upon entering the peritoneum, the first step should be confirmation that the mass is a PTC by identifying normal ovaries bilaterally. The fallopian tube should be identified to the fimbriated end, which can be challenging if the mass is large and the tube is distorted. With very large PTCs, it can be easier to find the fimbriated ends of the fallopian tube and work back to the cornua of the uterus. An incision can then be made in the broad ligament, away from the fallopian tube to avoid transection or injury, and the tissue plane between the underlying cyst and overlying broad ligament can be developed, either with hydro, blunt, or sharp dissection (**FIG. 43.9C**). The mass should be removed entirely. Broad ligament hemostasis can be achieved with electrocautery or placement of suture. When PTCs are very large, the mass may need to be punctured and decompressed to facilitate removal (**BOX 43.5**). The low risk of recurrence justifies avoiding salpingectomy.

## BOX 43.5 STEPS IN THE PROCEDURE

### Removal of Paratubal Cysts

- Confirm diagnosis by identifying normal ovaries.
- Confirm location of fallopian tube and fimbriated end.
- Make incision in the broad ligament over the paratubal cyst.
- Separate the cyst from the overlying broad ligament by sharp or hydrodissection.
- Remove the paratubal cyst.

- Obtain hemostasis in the broad ligament by electrocautery or suture.

# Adnexal Torsion

Adnexal torsion is a surgical emergency with an incidence of 4.9 per 100 000 in women younger than 20 years. Adnexal torsion most commonly involves twisting of both the tube and ovary, with isolated ovarian or tubal torsion less likely. Most adnexal torsions are due to adnexal pathology including benign cystic teratomas or hemorrhagic ovarian cysts and less commonly PTCs, cystadenomas, or hydrosalpinx. Torsion of normal adnexa is more common in premenarchal patients, hypothesized to be due to a relatively smaller uterus and longer utero-ovarian ligaments compared to adult women.

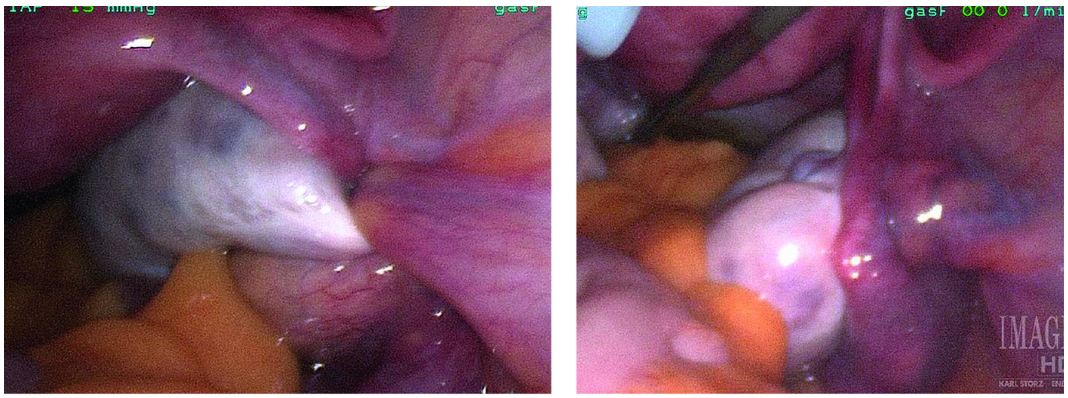
Adnexal torsion is a clinical diagnosis and requires a high index of suspicion since there is no laboratory or imaging study that rules out or confirms the diagnosis. Patients typically complain of acute abdominal or pelvic pain, at times accompanied by nausea and vomiting or anorexia. Physical findings may include tachycardia, low-grade fever, and localized abdominal tenderness with possible rebound. Transabdominal pelvic ultrasound with color Doppler studies to assess blood flow to and from the adnexa is the most helpful radiologic tool when evaluating patients with suspected adnexal torsion. Unfortunately, the presence or absence of Doppler flow does not exclude or confirm the diagnosis of torsion. Ultrasonographic findings that raise suspicion of adnexal torsion include unilateral enlarged ovary or asymmetrical ovarian enlargement, heterogeneous enlargement of one ovary due to edema, the presence of a simple or complex adnexal mass, present or diminished/absent flow on color Doppler, peripherally displaced follicles due to stromal edema from ischemia, medialization of the ovary, displacement of the uterus from the midline, free pelvic fluid, and the whirlpool sign, defined as twisting of the ovarian pedicle causing twisting of vessels.

Patients with suspected adnexal torsion require immediate surgical intervention, typically diagnostic laparoscopy. In patients

with suspected torsion, relief of symptoms, confirmation of the diagnosis, and ovarian preservation are the goals of surgery. Prompt surgical intervention is important to decrease the likelihood of irreversible adnexal damage, including necrosis and autoamputation.

Historically, the risk of missing an underlying malignancy, thromboembolism after detorsion, and belief that black and hemorrhagic ovaries are irreversibly damaged were arguments for oophorectomy. Fortunately, ovarian malignancies are rare in young patients; the risk of ovarian malignancy at the time of adnexal torsion is estimated at 2%. If the appearance of the ovary suggests malignancy, an ovarian biopsy should be performed at the time of detorsion. Thromboembolism is only a theoretical concern, as the incidence of pulmonary embolism associated with adnexal torsion is 0.2%. And lastly, even black, hemorrhagic ovaries, which do not change color after detorsion, demonstrate follicular development and normal Doppler flow as early as 6 weeks after detorsion.

Contemporary management of adnexal torsion focuses on ovarian preservation and the first step involves detorsion (**FIG. 43.10A AND B**). If a mass is present, cystectomy is performed, if feasible, to prevent recurrent torsion. A torsed, enlarged ovary may remain hemorrhagic or edematous after detorsion, making identification of a discrete mass and/or cystectomy impossible. In this situation, a staged approached is recommended. A pelvic ultrasound is repeated at least 6 weeks postoperatively to identify any underlying mass after resolution of the edema and hemorrhage. If a mass is identified, preoperative risk stratification and definitive surgery can be performed (**BOX 43.6**).



A B

**FIGURE 43.10 A.** Adnexal torsion. The ovary appears swollen, blackened, and hemorrhagic due to torsion. **B.** Completely detorsed adnexa. The ovary has resumed its normal appearance and swelling had decreased. (Courtesy of Geri D. Hewitt, Chief, Department of Obstetrics and Gynecology, General Division Obstetrics and Gynecology, Nationwide Children's Hospital, Columbus, Ohio.)

## BOX 43.6 STEPS IN THE PROCEDURE

### Management of Adnexal Torsion

- Detorse adnexa.
- Perform cystectomy, if feasible, if mass is present.
- Biopsy ovary if there is concern for malignancy.
- Consider oophoropexy in select cases.
- Order postoperative imaging if detorsed ovary is enlarged, edematous, or hemorrhagic to rule out underlying mass.

Despite universal acceptance of conservative intervention for premenopausal women with adnexal torsion in the literature, many patients are still being treated with oophorectomy. Campbell et al. reported on 1151 patients aged 18 years or less in the Pediatric Health Information System (PHIS) who were treated for adnexal torsion in the 5 years prior to December 31, 2011 and found 38% underwent oophorectomy.

The risk of recurrent adnexal torsion is ~5%. The risk of recurrence may be higher in patients who experienced torsion of normal adnexa. As direct result of conservative management of adnexal torsion, more patients may be at potential risk of recurrent torsion.

# Oophoropexy

Oophoropexy is a surgical procedure that limits ovarian mobility and decreases likelihood of adnexal torsion. The role of oophoropexy remains controversial and does not completely eliminate the risk of recurrent torsion. Questions surrounding oophoropexy include potential risks and benefits, patient selection, as well as timing and type of procedure. There are no definitive recommendations regarding oophoropexy and long-term follow-up data are not available. The strongest support for performing oophoropexy is in cases involving torsion of normal adnexa, recurrent torsion, bilateral torsion, and for the contralateral ovary when the torsed ovary was removed. However, risks of this procedure include possible negative impact on fertility and interference with tubal blood supply, compromised tubal function, or tubo-ovarian communication. While performing oophoropexy at the time of original surgery for detorsion may decrease the likelihood of additional surgery, delaying the procedure would allow for more complete counseling with patients and families and offer technical advantages if the adnexa are very edematous at the time of the original surgery.

There are two general types of oophoropexy procedures, those that shorten the utero-ovarian ligament and those that fix the ovary to surrounding structures. Comparative efficacy and safety data between the two types of procedures is lacking. Utero-ovarian

ligament plication may offer the advantage of restoring normal ligament length and decreased alteration of tubo-ovarian communication. Alternatively, the ovary may be fixed to the pelvic side wall, ipsilateral round ligament, or posterior aspect of the uterine fundus. Most authors recommend using absorbable suture at the time of oophoropexy. Both procedures can be performed laparoscopically.

# KEY POINTS

- While state laws vary, most states require consent from a parent and/or guardian for medical care including surgical procedures for patients <18 years. As developmentally appropriate, minor patients should be included in preoperative counseling and their assent should be obtained.
- Consultation with pediatric experts should be requested regarding prophylactic antibiotic dosing, NPO requirements, VTE prophylaxis, instrumentation, patient positioning, and postoperative pain management.
- Examination under anesthesia with vaginoscopy is used to assess the proximal vagina and cervix in young patients. The most common indications are bleeding, persistent vaginal discharge, trauma beyond the hymen, suspected foreign object, and various congenital conditions.
- Hymenal variants are repaired ideally after thelarche by resection of excessive hymenal tissue and achieving hemostasis with interrupted stitches of absorbable suture. Some hymenal abnormalities can be repaired in the office using local anesthesia.
- Genital injuries are a result of accidental and nonaccidental causes. Evaluation should focus on ruling out abuse and assessing the extent of the injury. Prerequisites for conservative management are the ability to void spontaneously, presence of only minimal bleeding, and successful assessment of the extent of the injury on examination. Repair of extensive injuries may

involve multiple organs and require collaboration with other specialists.

- Laparoscopy performed in the pediatric age group requires smaller instruments, additional care on entry, lower rates of insufflation, and lower intra-abdominal pressures.
- Most ovarian neoplasms in children and adolescents are benign. Surgical treatment for ovarian masses is determined by clinical presentation and preoperative risk stratification using radiologic imaging and serum tumor marker panels. Patients at low risk of malignancy benefit from ovarian cystectomy. Oophorectomy with surgical staging should be reserved for patients with a high risk of malignancy based on preoperative risk stratification.
- Paratubal cysts are more common in obese adolescents and are infrequently seen prior to menarche. Paratubal cysts should be removed entirely, with care to avoid injury to the fallopian tube. Patients may be asymptomatic or present with adnexal or tubal torsion.
- Adnexal torsion should be treated conservatively with detorsion and not oophorectomy since the risk of underlying malignancy, thromboembolic events, and ovarian necrosis and sepsis are very small. If an ovarian mass is present, ovarian cystectomy should be performed at the time of detorsion if feasible.
- Oophoropexy remains controversial but is most widely accepted in cases of recurrent torsion, bilateral torsion, torsion of normal adnexa, and if the contralateral ovary has been removed. The two types of oophoropexy described are those that shorten the utero-ovarian ligament and those which fix the ovary to surrounding structures.

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# CHAPTER 44

# SURGERY FOR OBSTETRIC HEMORRHAGE

Jason D. Wright and Fady Khoury-Collado

**General Principles of Management of Obstetrical Hemorrhage**
Early and Comprehensive Assessment
Timely Intervention
Adequate Resuscitation
Communication
Positioning, Incision, and Exposure
**General Measures to Control Obstetrical Hemorrhage**
Aortic Compression
Use of Tourniquet
Pelvic Packing
**Surgical Intervention for Obstetrical**
Uterine Atony
Hypogastric Artery Ligation
**Surgical Management of Hemorrhage due to Other Causes**
Uterine Rupture
Uterine Laceration or Extension of Uterine Incision
Management of a Broad Ligament and Retroperitoneal Hematoma

**Peripartum Hysterectomy**

Hysterectomy for Uterine Atony

Hysterectomy for Placenta Accreta Spectrum

**Postoperative Care**

**Conclusion**

Obstetrical hemorrhage is a major cause of preventable maternal morbidity and mortality worldwide. Hemorrhage causes 8% of maternal deaths in developed regions and up to 20% in developing regions. The incidence of postpartum hemorrhage (PPH) has been increasing in the last decade and ~11% of maternal deaths in the United States are associated with PPH. Many of the adverse outcomes associated with maternal hemorrhage can be prevented through the implementation of timely and effective interventions. Life-threatening bleeding often takes place in women with no risk factors, and therefore, a constant level of vigilance and preparedness is mandatory in any labor unit.

During pregnancy, the blood flow to the uterus will increase to reach about 600 mL/min at term. This explains the rapid deterioration that occurs with uncontrolled blood loss from the pregnant or postpartum uterus, which can quickly lead to severe anemia and hypoxia, hypoperfusion of vital organs, acidosis, coagulopathy, severe electrolyte disturbances, multisystem organ failure, and death.

Postpartum hemorrhage (PPH) is currently defined as a blood loss of 1000 mL or more, or blood loss associated with signs or symptoms of hypovolemia, irrespective of the mode of delivery. The causes of PPH have been classically summarized as the four T's: tone (uterine atony), trauma (rupture, laceration), tissue (retained placenta), and thrombin (clotting factor deficiency). The most common cause of hemorrhage is uterine atony (70%), followed by obstetrical lacerations (20%), retained placenta (10%), and clotting factor deficiency <1%.

Many of the adverse outcomes associated with maternal hemorrhage can be prevented through the implementation of timely and effective interventions. Life-threatening bleeding often takes place in women with no risk factors, and therefore, a constant level of vigilance and preparedness is mandatory in any labor unit. Given the limited availability of controlled surgical trials for this condition, much of the evidence supporting the procedures described in this chapter comes from case series, nonrandomized cohorts, and expert opinion.

# GENERAL PRINCIPLES OF MANAGEMENT OF OBSTETRICAL HEMORRHAGE

Hemorrhage can occur in any obstetrical patient in the absence of known risk factors. A high level of vigilance should be maintained in any labor unit, and systems should be in place to allow for rapid interventions. A successful outcome will depend on the ability to act quickly, the availability of resources, and the experience of the team.

## Early and Comprehensive Assessment

A comprehensive assessment of the patient with suspected bleeding should include prompt and repeated clinical and laboratory assessments with attention to subtle changes that may be the earliest signs of ongoing bleeding. Partial assessments of isolated clinical variables can be misleading, especially to the unexperienced provider, and may lead to precious time lost. For example, a stable blood pressure can provide false reassurance, since the blood pressure may not start to decrease until a significant amount of blood loss has already taken place. Similarly, a small amount of vaginal bleeding may not correlate with a more significant amount of bleeding taking place in the abdomen or in the retroperitoneum.

# Timely Intervention

An important aspect in deciding to offer surgical intervention for PPH is making a timely decision. For example, a hysterectomy for uterine atony should not be technically difficult and should resolve PPH with a favorable outcome. However, if the decision to proceed with an indicated hysterectomy for PPH is delayed until the patient has become unstable or coagulopathic, the hysterectomy will become more difficult with a higher risk of adverse outcomes.

# Adequate Resuscitation

An equally important aspect of the surgical management of PPH is adequate intraoperative resuscitation, especially in the presence of significant and ongoing blood loss requiring large volume transfusion of blood products. Adequate intravenous access is essential either through two large bore peripheral lines or a central line. An arterial line is strongly recommended for hemodynamic monitoring and can facilitate blood draws as well. Although the primary focus of the resuscitation is to replace the blood loss and coagulation factors, it is equally important to be mindful that severe electrolyte abnormalities can develop, specifically hypocalcemia and hyperkalemia which if not monitored and corrected in a timely fashion, can lead to fatal arrhythmias despite successful surgical control of the bleeding. Once a massive transfusion protocol is initiated, and as long as the patient is bleeding and receiving blood product transfusion, monitoring hematologic and metabolic panels on a regular basis is essential.

# Communication

Constant communication between the surgeon, anesthesiologist, and operating room team is critical to coordinate the surgical and resuscitative effort. The surgeon may need to temporize his surgical effort by packing the pelvis and applying pressure to give time to the anesthesiologist to replace the blood loss, check and correct any electrolyte abnormalities and acidosis, before resuming the surgical work. These intentional “breaks” in the surgical effort are invaluable

and allows time for all the members of the team in the operating room to regroup and communicate about the status of the patient, the surgical plan, any additional resources needed, and additionally may decrease the stress often created by these situations.

## Positioning, Incision, and Exposure

When possible, it is preferred to have the patient in a lithotomy position rather than in a supine position. The lithotomy position allows for direct monitoring of any ongoing vaginal bleeding, provides improved access to the pelvis for surgical assistants, and facilitates several interventions that may be required during the surgery (eg, placement of a vaginal retractor to outline the vaginal fornix, retrograde filling of the bladder, cystoscopy). In patients who have undergone a cesarean delivery, reopening the transverse incision is appropriate and usually will allow for adequate exposure. In patients who delivered vaginally, the decision for the type of incision will need to be individualized depending on the suspected etiology of the bleeding and the hemodynamic status. A midline vertical incision will provide the quickest entry into the abdomen and the best exposure and is the preferred incision in the hemodynamically unstable patient or when the etiology of the bleeding has not been identified. A Pfannenstiel incision is acceptable when the patient is relatively hemodynamically stable, and the etiology of the bleeding is suspected to be from the uterus (uterine atony) as the laxity of the postpartum abdomen will allow for adequate exposure of the pelvic sidewalls, and the need for upper abdominal exploration is minimal. Use of a self-retaining retractor is preferred to obtain adequate exposure of the pelvis. Retractor options include a Balfour retractor, a wound protector, or a table mounted retractor (Omni, Bookwalter). A wound protector is fast and easy to place and provides adequate exposure of the pelvis in most cases, including cases of placenta accreta spectrum with a large midline incision. After entry into the abdomen, a systematic search of all possible sources of bleeding is undertaken in a relatively brief amount of time. Often the source of bleeding is known and easily identified. Alternatively, the source of the bleeding may not be readily

apparent, and this can be either be due to retroperitoneal bleeding or bleeding originating from the upper abdomen, albeit a rare but possible occurrence (eg, rupture of a splenic artery aneurysm or a hepatic hematoma).

# GENERAL MEASURES TO CONTROL OBSTETRICAL HEMORRHAGE

## Aortic Compression

Manual compression of the lower aorta, above the iliac bifurcation, can be performed in the presence of severe and life-threatening bleeding, which is yet to be controlled either because the source of bleeding has not yet been identified or when exposure of the pelvis is difficult due to an excessive amount of active hemorrhage. This maneuver can be performed by simple manual compression against the lower spine, or with the use of a sponge on a stick. The time at which the compression is initiated should be stated clearly to avoid lower limb ischemia. The blood flow to the uterus and pelvis may not be completely interrupted because blood continues to flow through collateral networks such as the ovarian vessels, but flow will be significantly reduced to allow exposure of the pelvis while resuscitative efforts are ongoing. Endovascular balloon occlusion of the lower aorta has been used to achieve this same goal (see **FIG. 44.1**).

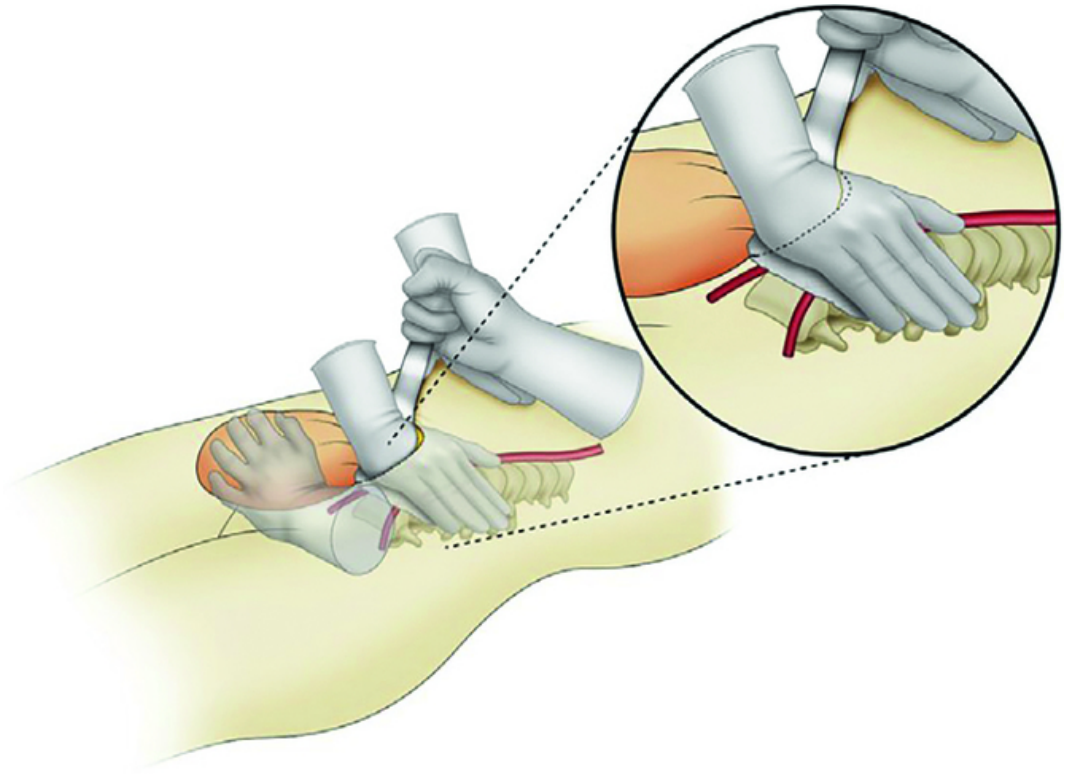

**FIGURE 44.1** Manual compression of the lower aorta, above the iliac bifurcation, can be performed in the presence of severe and life-threatening bleeding. (Reprinted from Nieto-Calvache AJ, Palacios Jaraquemada JM, Basanta N, et al. Internal manual compression of the aorta-an effective way to temporarily control pelvic bleeding in obstetrical hemorrhage. *Am J Obstet Gynecol*. 2022;227(1):96-97, Figure 1, with permission from Elsevier.)

## Use of Tourniquet

Tying a tourniquet around the uterine isthmus is a simple maneuver that can provide temporary control of the bleeding from the uterine fundus by occluding both uterine arteries at the level of the isthmus. This maneuver will also gain some time to allow the surgeon to complete the planned surgical procedure on the uterus (repair of rupture, partial excision of the myometrium). The tourniquet effect can be achieved by circling the isthmic part of the uterus with a Penrose drain or similar device. A Penrose drain is placed around the uterine isthmus or lower uterine segment and may include the ovarian vessels if needed. In the first alternative, a window is created in the avascular portion of the lower part of the broad ligament at the level of the isthmus on each side. The drain is passed through the avascular windows, and the two ends of the drain are pulled while being crossed over each other 2-3 times, and then maintained in place with a clamp, creating a mechanical occlusion of the uterine arteries. In this situation, the blood flow from the ovarian vessels remains patent.

If the blood supply to the uterus coming from the uterine arteries and the ovarian vessels needs to be completely interrupted, the tourniquet is placed over the isthmic area of the uterus without creating windows in the broad ligament. In this situation, the ovarian vessels are included in the tourniquet and blood flow from the ovarian vessels is interrupted as well. Care should be taken to not to injure the ovarian vessels during this process (see **FIG. 44.2**).

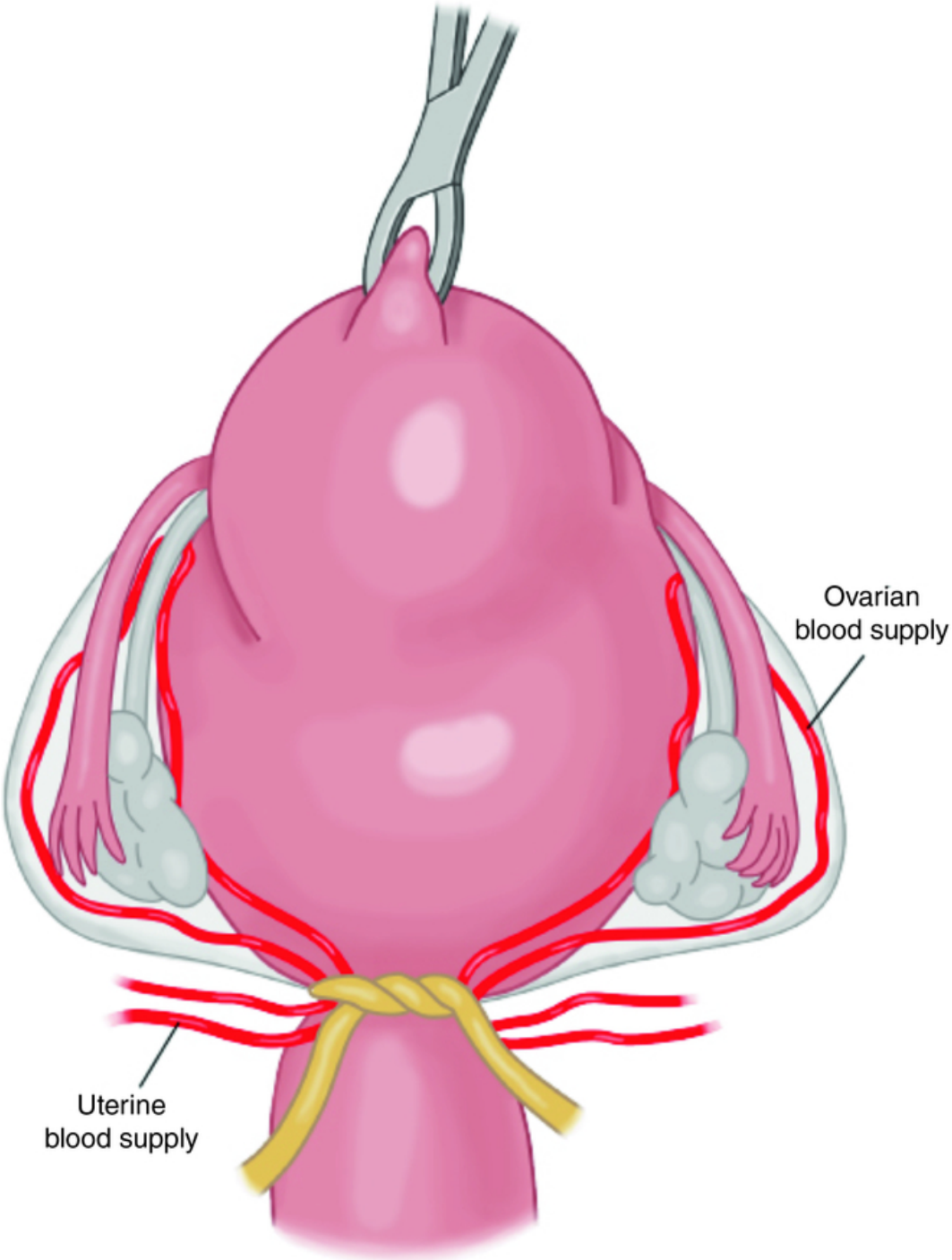


**FIGURE 44.2** Placing a tourniquet at the level of the isthmus after creating windows in the broad ligament can significantly decrease the amount of bleeding. (Copyright © 2022

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The tourniquet effect can also be achieved by manually circling the isthmus between the thumb and index fingers of the surgeon or assistant and holding pressure. This maneuver is very helpful when the superior attachments of the uterus have already been divided as a hysterectomy is progressing, and continuous bleeding from the uterine fundus is taking place.

Successful application of a tourniquet on the isthmus may stop or significantly decrease bleeding from the uterine fundus but may have little effect on bleeding from the cervix or vaginal walls. This is an important detail, especially in patients with placenta accreta spectrum, where the placenta can be invading the cervix or upper vagina and perfused by an extensive network of collaterals independent from the uterine artery.

## Pelvic Packing

Pelvic packing has an essential role in the management of PPH, and at times can be the most important action performed by the surgeon. It can be used in several instances, with different goals. In the initial evaluation after abdominal exploration, it can be used as a temporizing measure. Later in the case, it can be the single most important intervention to achieve hemostasis when the pelvic bleeding is diffuse and difficult to control surgically, such as in the presence of a coagulopathy, or when bleeding is originating from an area that is difficult to expose adequately (pelvic sidewall venous plexus). Typically, this is performed by placing several laparotomy pads in the pelvis and applying pressure with the surgeon's fist. The use of hemostatic agents in addition to packing should be considered, especially when a coagulopathy is present. After packing, the pelvis can be evaluated in 5-minute intervals. This is repeated until adequate hemostasis is achieved. In cases where persistent packing is felt to be needed to achieve hemostasis, consideration is given to the use of sheets of resorbable hemostatic

material that can be left in pelvis. In severe cases, it may take 30-45 minutes to achieve hemostasis. In situations requiring prolonged packing, covering the incision and the abdominal contents with warm, moist laparotomy pads will minimize abdominal heat loss.

# SURGICAL INTERVENTION FOR OBSTETRICAL

## Uterine Atony

Uterine atony is the most common cause of PPH. The first line of treatment (and most often successful) is nonsurgical and includes the use of uterotonic agents and uterine massage. The next line of intervention is placement of an intrauterine balloon to tamponade the uterine walls (eg, Bakri balloon) or more recently, the placement of a vacuum-induced tamponade device, with consideration of uterine artery embolization if the patient is in a relatively stable condition with small but continuous bleeding. When these interventions fail, or the bleeding resulting from atony has accumulated to an amount where systemic consequences are likely, a strong consideration should be given to proceed with surgical interventions (see **FIG. 44.3**).

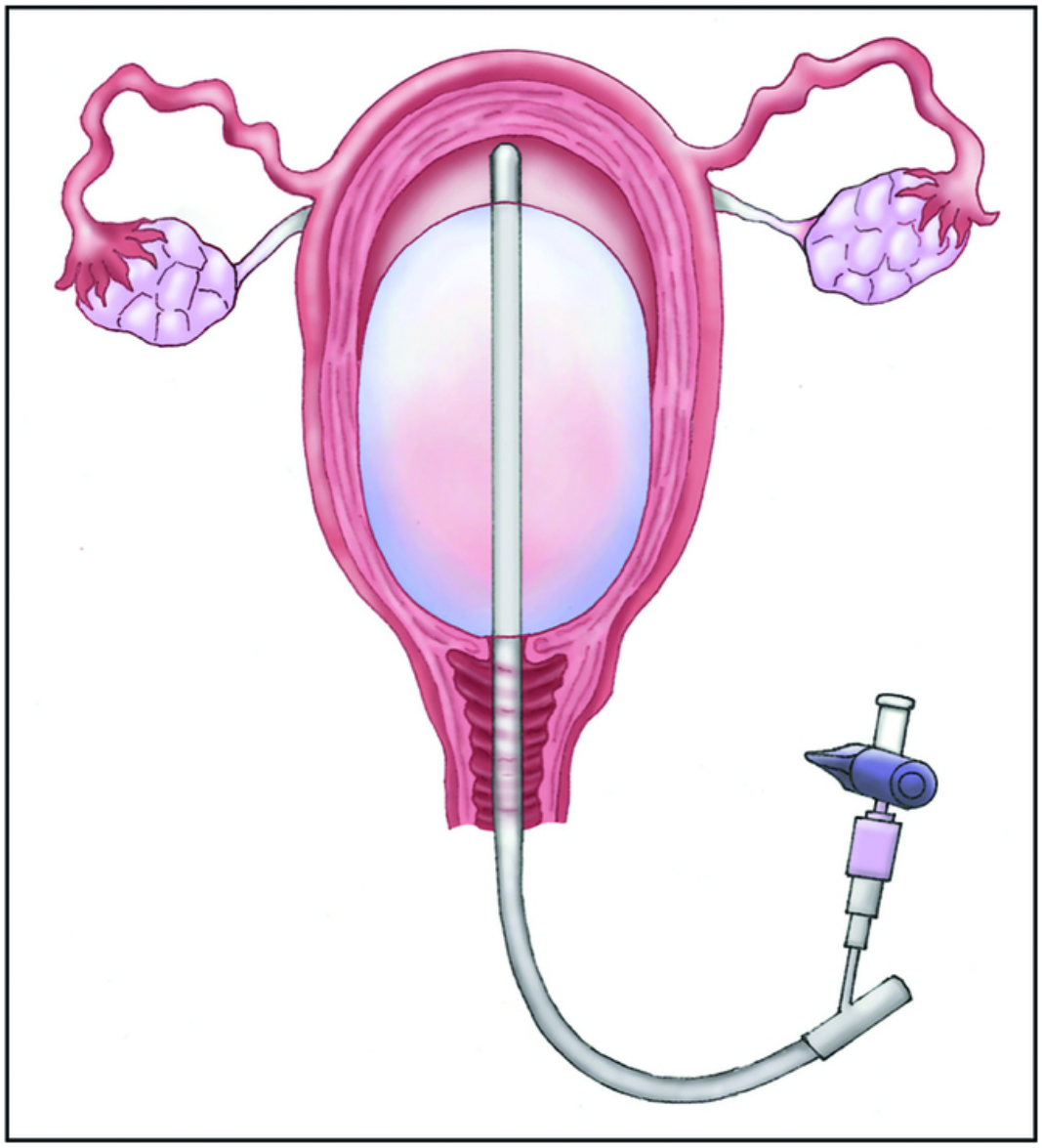

**FIGURE 44.3** A Bakri balloon can be placed to tamponade the uterine walls in cases of atony. (Reprinted from Suarez S, Conde-Agudelo A, Borovac-Pinheiro A, et al. Uterine balloon tamponade for the treatment of postpartum hemorrhage: a systematic review and meta-analysis. *Am J Obstet Gynecol.*

2020;222(4):293.e1-293.e52, Figure 2, with permission from Elsevier.)

Placement of uterine compression sutures is another effective option for management of uterine atony that does not respond to uterine massage and uterotonics. The rationale for this approach is to compress the uterus by placement of sutures wrapped around the fundus. Placement is also indicated when a focal area of the fundus is thinned out and not contracting appropriately. Uterine compression sutures can be combined with uterine artery ligation in case of persistent bleeding after placement of the compression sutures, and in combination with balloon tamponade, the balloon typically being placed prior to the placement of compression sutures.

The most common approach for uterine compression is the B-Lynch suture. Using a large needle and a rapid absorption suture (the authors use a chromic catgut no. 2 loop suture), the suture enters the anterior lower uterine segment laterally and is looped over the uterine fundus to enter on the opposite side of the posterior lower uterine segment. The suture then crosses to the contralateral side, is looped back over the fundus, and enters the opposite anterior lower segment, at the same level as the initial needle entry. Both suture ends are then tied while the uterus is compressed by the assistant. Several modifications of the compression sutures have been described. There have been no direct head-to-head studies of the different techniques so the surgeon can use their preferred approach. In patients with a successful outcome following the placement of uterine compression sutures, long-term fertility and pregnancy are unaffected in most cases. Rare complications reported include uterine necrosis and the development of uterine synechiae (see **FIG. 44.4**; **BOX 44.1**).

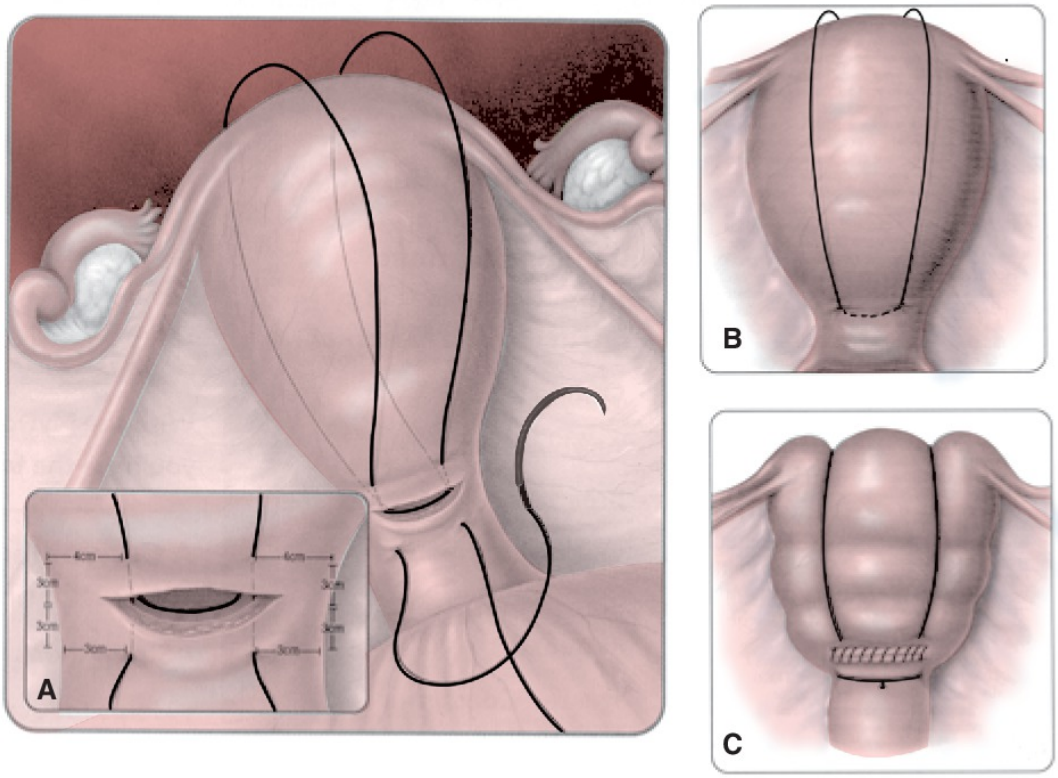


**FIGURE 44.4** Technique of B-Lynch suture placement. **A.** The initial bite is placed anteriorly at one angle of the uterine incision (see **inset**). **B.** After the anterior B-Lynch suture is placed, the suture is passed over the fundus, a deep transverse bite is taken in the posterior lower uterine segment, and the suture is passed back over the fundus. **C.** The suture is then tied to provide compression of the uterus.

## BOX 44.1 STEPS IN THE PROCEDURE: B-LYNCH SUTURE

Using a large needle and a rapid absorption suture such as chromic catgut no. 2 loop suture.
Place the suture in the lower uterine segment laterally.
Loop suture over the uterine fundus to enter on the opposite side in the posterior lower uterine segment.
Suture crosses to the contralateral side, is looped back over the fundus, and enters the opposite anterior lower segment, at the same level as the initial needle entry.
sBoth suture ends are then tied while the uterus is compressed by the assistant.

When the surgical objective includes preservation of the uterus, surgical ligation of the vessels supplying the uterus may be considered. Vessel ligation will interrupt the flow from the uterine arteries and can include the ovarian vessels. The initial step is to occlude the uterine vessels, while leaving the ligation of the ovarian vessels as an adjunctive step attempted in case of failure of the first one, and as a last step before making the decision to proceed with hysterectomy.

Uterine artery blood flow to the uterus can be interrupted at several levels. The classical O'Leary stitch is described as suture ligation of the uterine arteries at the level of the isthmus, without the need to dissect the uterine artery. The suture is passed from the lateral aspect of the lower segment and through the broad ligament lateral to the uterine artery and then tied. This is performed bilaterally, with consideration given to placing two similar sutures at the cornual level to ligate the anastomotic branch from the utero-ovarian ligament. If the lower segment suture is placed too close to the cervix, there is increased risk of ligating or kinking the ureter. In all cases, it is advisable to document the integrity of the ureter after successful placement of these stitches, preferably by entering the retroperitoneum and visualizing the ureter. If this is not possible, performing cystoscopy and visualizing efflux of bilateral ureteral jets is reassuring (see **BOX 44.2**).

## BOX 44.2 STEPS IN THE PROCEDURE: PLACEMENT O'LEARY STITCH

- Pass the suture from the lateral aspect of the lower segment through the broad ligament lateral to the uterine artery, bilaterally.
- Tie suture
- Can place second set of similar sutures at the cornual level to ligate the anastomotic branch from the utero-ovarian ligament.

An alternative option, when expertise in radical dissection of the parametria is available, is to ligate the uterine artery directly. The pararectal space is developed between the ureter and the hypogastric artery, and the uterine artery is identified as it originates from the hypogastric artery. At this level, the uterine artery can be occluded with a hemoclip, by a vessel sealing device, or by suture ligation. Given the amount of collateral blood supply to the uterus, successful control of bleeding with bilateral uterine artery ligation does not seem to affect fertility outcomes (see **FIGs. 44.5 and 44.6**).

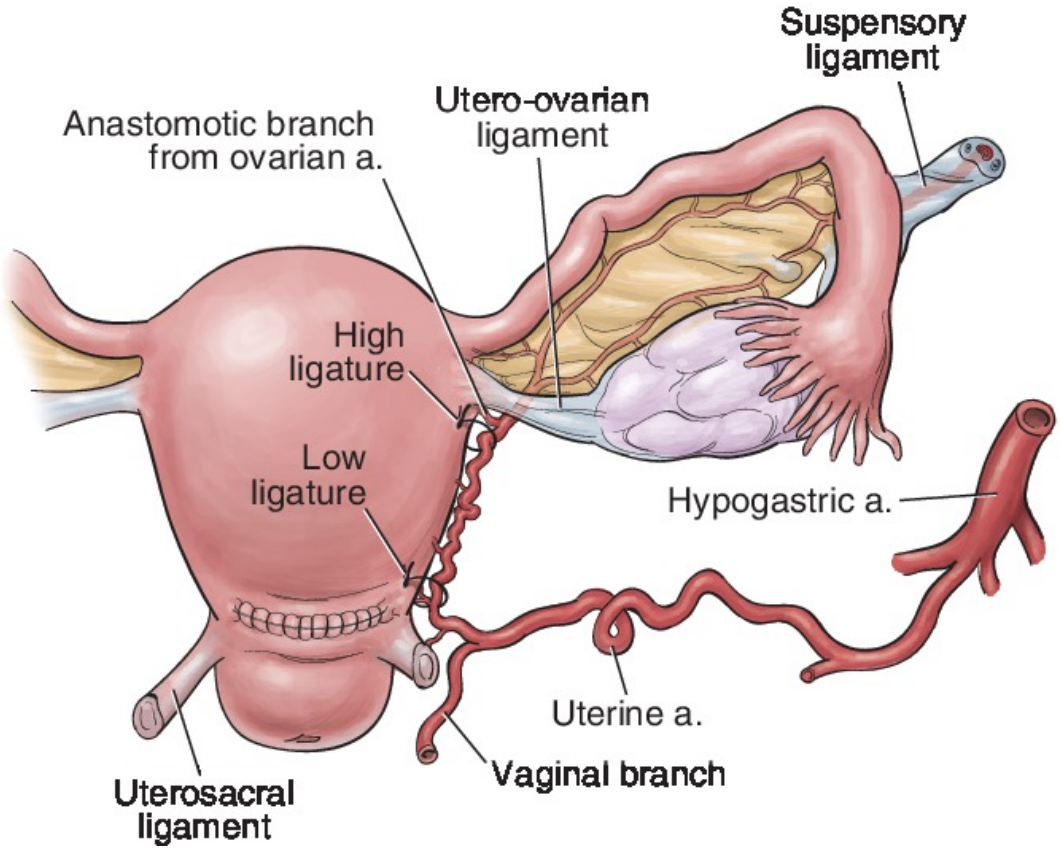


**FIGURE 44.5** Uterine artery ligation.

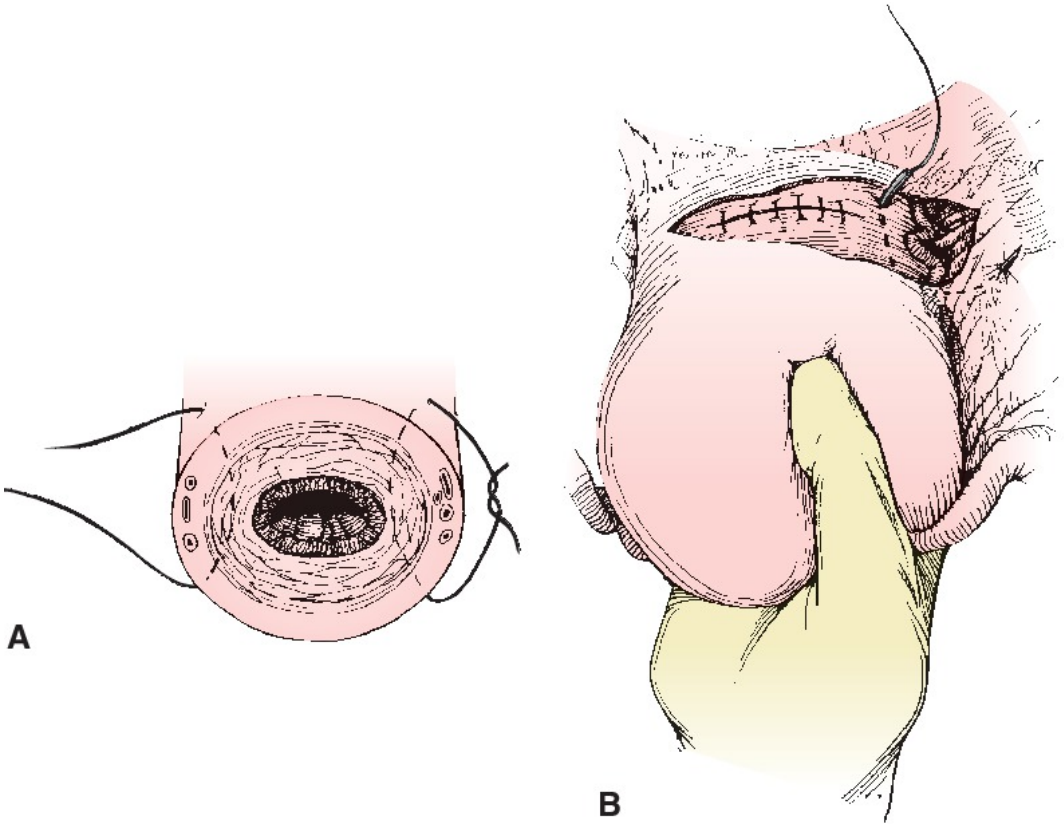


**FIGURE 44.6** Uterine artery ligation. **A.** Lateral view demonstrating ligature placement. **B.** Anatomic relation of ligature to uterine wall and vessels. (Reprinted from Floyd RC, Morrison JC. Postpartum hemorrhage. In: Plauche WC, Morrison JC, O'Sullivan MJ, eds. *Surgical Obstetrics*. 1st ed. WB Saunders; 1992:272. Copyright © 1992 Elsevier. With permission.)

## Hypogastric Artery Ligation

Although classically described as an intervention to be considered in the management of PPH, it is rarely used, and in our experience is of uncertain effectiveness. Given the extensive collateral network in the

pelvis, ligating or occluding the hypogastric vessels will not achieve a complete interruption of the blood flow to the uterus; however, bilateral ligation has been shown to decrease the pulse pressure of blood flow to the uterus. This procedure is technically demanding, and most obstetricians and pelvic surgeons will not be comfortable performing it.

At this time, there is no specific cause of PPH for which it is specifically indicated, and it remains an option used at the individual surgeon's discretion. The authors rarely use this technique in the management of PPH and believe the other options described are more appropriate, more likely to achieve hemostasis.

To perform hypogastric artery ligation, the retroperitoneal space is entered, lateral to the ovarian vessels. The ureter is identified and mobilized medially. The dissection of the hypogastric artery can proceed in two directions, either from proximal to distal, starting at the bifurcation of the common iliac artery, or from distal to proximal, by identifying the obliterated umbilical artery and moving proximally. The choice of approach depends on the ease of exposure in each patient and the surgeon's preference.

In the proximal to distal approach, the iliac bifurcation is identified. The dissection of the hypogastric artery proceeds distally until it starts to diverge from its proximity to the external iliac vein. Soon after, the hypogastric will continue as the obliterated umbilical artery. Using gentle blunt dissection with either the index finger or a right-angle clamp, the distal hypogastric artery is elevated from the underlying connective tissue and can be occluded with a hemoclip or suture ligation without division of the artery. If the ligation is attempted at a more proximal level of the hypogastric artery, there is an increased risk of injury of the external iliac vein due to its proximity, and risk of buttock ischemia in case of ligation proximal to the posterior branch of the hypogastric artery. In the distal to proximal approach, the dissection starts by identifying the obliterated umbilical artery and proceeds in proximal fashion until the desired level of occlusion is reached.

# SURGICAL MANAGEMENT OF HEMORRHAGE DUE TO OTHER CAUSES

## Uterine Rupture

The surgical management of a uterine rupture will depend on the extent of the rupture. When rupture is associated with an overall preservation of the uterine anatomy, surgical repair can be performed as would be performed in repair of a hysterotomy. Extension of the rupture line laterally should prompt the surgeon to identify the ureter before the uterine repair is performed. If the uterine rupture leads to a complete distortion of the uterine anatomy with inability to reconstruct the uterus and restore normal anatomy, proceeding with hysterectomy without delay is the appropriate plan. In this case, and depending on the amount of distortion, the usual anatomical landmarks (round ligaments, uterine isthmic area, cervix) may be more difficult to identify. It is useful in this situation to start by identifying the ureters by entering the retroperitoneal space, and then proceeding with successive control of vascular pedicles that may have been avulsed. The ureter is dissected from the pelvic brim and as deep in the pelvis as needed, typically until its insertion into the bladder. During this process, clamping and suture ligating of the uterine attachments (even without the ability to identify normal uterine anatomy) can be performed with the ureters under visualization.

At times, the rupture line can extend to include the anterior or posterior vaginal walls. When the rupture line involves the anterior vaginal wall, it is important to assess the integrity of the bladder and the distal ureters, as these course in close relationship to this part of the vaginal wall. When the rupture line involves the posterior vaginal wall, it is important to be mindful of the proximity of the rectum. After completion of hysterectomy, the posterior vaginal cuff can then be grasped with long clamps (ie, Allis clamps) and elevated. An assessment of the proximity of the rectum can be made at this time,

and if needed, the rectovaginal space developed, and the rectum mobilized caudally before proceeding with the vaginal repair.

## Uterine Laceration or Extension of Uterine Incision

Uncontrolled extension of the uterine incision to the cervix and vaginal wall and/or a laceration of the uterine vessels leading to bleeding in the broad ligament can be encountered during cesarean delivery. Clinical scenarios can increase the risk of uterine laceration, including a prolonged labor with a dilated and thin lower uterine segment, an inappropriately small uterine incision, or an incision made too low on the uterus. A laceration can also occur following an operative vaginal delivery with upward extension of a vaginal laceration into the cervix and lower uterus.

The repair of the laceration should start by assessing the extent of the laceration and the structures involved. The edges of the laceration are grasped with Allis clamps to delineate the limits of the repair. It is important to be gentle when handling the tissues, as they are typically friable and excessive traction can lead to additional bleeding and/or worsening of the laceration.

If the laceration only involves the fundal myometrium, the defect is repaired primarily with a series of interrupted sutures or a running suture.

When the laceration has extended into the broad ligament or caudally to involve the cervix or upper vagina, it is imperative to identify the ureter before starting the repair. In cases of significant bleeding rendering dissection of the lateral pelvis difficult, packing and pressure can be attempted with intermittent exposure of the area of interest, until the ureter is identified and mobilized laterally.

Avulsed vessels should be identified and controlled individually with either hemoclips or by suture ligation. Once the ureter has been identified, the repair of the cervicovaginal laceration can proceed using either continuous or interrupted sutures. When repairing the vaginal component of the laceration, it is important to minimize traction on the vaginal wall, which is often very thin and friable, to

avoid an extension of the laceration. In some cases, the vaginal fornix may be completely avulsed from the cervix and will need to be reattached by a series of interrupted sutures, taking care not to occlude the cervical canal. Placing an instrument transvaginally such as a cervical dilator into the uterine cavity during the repair can protect the cervical canal.

After completion of the repair, the ureter is examined along its path to document its integrity. It is not uncommon for a small amount of bleeding originating from the friable parametrial tissue to occur. This is best controlled by packing and pressure, with or without the use of hemostatic agents. Additional attempts of suture ligation of friable tissue may be counterproductive and lead to additional bleeding.

## Management of a Broad Ligament and Retroperitoneal Hematoma

A broad ligament or retroperitoneal hematoma can develop following a cesarean or vaginal delivery. If the patient is stable, the hematoma is not expanding, and the uterine anatomy is preserved, expectant management is appropriate. On the other hand, if the hematoma is expanding, the uterine anatomy is distorted (by a laterally extended laceration or a concealed rupture) or the patient is unstable due to ongoing bleeding, the retroperitoneal space should be explored.

In this situation, the peritoneum is incised lateral to the ovarian vessels and the incision extended cephalad and caudad in a parallel fashion. If better exposure is needed, the round ligament can be divided. The next step is to identify the ureter and expose it from the pelvic brim. Individual bleeding vessels can then be identified and controlled. In the presence of diffuse small vessel bleeding, packing and pressure is recommended. If the bleeding originates from a uterine or vaginal laceration, these can be repaired as described earlier.

# PERIPARTUM HYSTERECTOMY

# Hysterectomy for Uterine Atony

When uterine atony does not respond to conservative management, it is important to make a timely decision to proceed with hysterectomy before the patient becomes unstable and develops a significant coagulopathy, acidosis, or multiorgan dysfunction. The surgical approach for a hysterectomy performed for atony is similar to a hysterectomy performed for a nonpregnant uterus. However, some additional aspects are worth emphasizing that can be more specific to a peripartum hysterectomy. A peripartum hysterectomy for uterine atony is performed in an acute setting, and some level of urgency is present. Once a decision is made to proceed with a hysterectomy for uterine atony, placing a tourniquet at the level of the isthmus after creating windows in the broad ligament can significantly decrease the amount of bleeding. The surgical approach of a hysterectomy performed for placenta accreta spectrum, a specific entity requiring a unique approach (see **BOX 44.3**).

## BOX 44.3 STEPS IN THE PROCEDURE

### Peripartum Hysterectomy for Placenta Accreta Spectrum

- Preoperative preparation and planning by a multidisciplinary team.
- Delivery is scheduled, typically at 34-36 weeks of gestation.
- Combined spinal epidural anesthesia is administered.
- Patient is placed in lithotomy position and vascular access established.
- All available staffing and blood products should be available prior to initiation of the procedure.
- Cystoscopy with placement of retrograde ureteral stents is preferred.

- Laparotomy and hysterotomy are performed, away from the placental bed.
- Hysterotomy site is closed without disruption of the placenta and the placenta left *in situ*.
- The retroperitoneal spaces are opened, and the round ligament, utero-ovarian ligament, and large veins of the broad ligament are individually skeletonized and divided. The fallopian tubes are excised.
- The ureters are identified and the posterior leaf of the broad ligament is divided.
- An assessment is made for lateral placental extension into the parametria and the pelvic sidewall.
- The bladder is retrograde filled to outline its superior limit.
- The vesicouterine peritoneum is opened and the bladder mobilized away from the uterus and placental bed with systematic division of vascular connections.
- Lateral placental attachments are divided with the ureter under direct visualization. If needed, the uterine artery can be divided in the parametria.
- Once the bladder is mobilized to the level of the anterior vaginal wall, the uterine arteries are divided at the level of the isthmus, unless previously divided in the parametria.
- An assessment is made whether the placenta is involving the cervix, and the decision is made to proceed with either a supracervical or total hysterectomy.
- The cardinal ligaments are divided and suture ligated to the level of the mid cervix (supracervical hysterectomy) or upper vagina (total hysterectomy), and the specimen amputated.
- The cervical stump or vaginal cuff is closed.
- Inspection of the surgical field to confirm adequate hemostasis, integrity of the bladder and ureters.

# Hysterectomy for Placenta Accreta Spectrum

Placenta accreta spectrum (PAS) is arguably the most challenging surgical condition in obstetrics. The anatomic distortion and the increased pelvic vascularity associated with this condition are responsible for the associated morbidity, primarily due to massive hemorrhage. Additional morbidity is related to the extrauterine growth of the placenta, primarily into the bladder, and more rarely into the pelvic sidewall, the pelvic vessels, or the bowel. This disorder is most often seen in patients with a history of prior cesarean delivery and placenta previa, the latter being another potential factor contributing to the risk of blood loss.

A multidisciplinary approach to the management of patients with PAS has been shown to be associated with improved outcomes. Given the complexity of this condition and the resources required, the multidisciplinary team should include experienced pelvic surgeons, an anesthesia team with expertise in massive resuscitation, critical care specialists, and a blood bank able to manage massive transfusions. The optimal surgical approach to manage patients with PAS has not been established, given the limited prospective controlled data available. However, there is relative consensus on some aspects of the surgical approaches (ie, hysterectomy with placenta *in situ*, placement of ureteral stents) mostly based on retrospective single institution experiences. Other approaches commonly used by many groups remain controversial, including the role of conservative management and delayed hysterectomy (see **TABLE 44.1**).

## TABLE 44.1
## Criteria Accreta Centers of Excellence and Guidelines for Referral to Centers of Excellence

| Suggested Criteria for Accreta Center of Excellence | |
|---|---|
| Multidisciplinary team | • Experienced maternal-fetal medicine physician or obstetrician<br>• Imaging experts (ultrasound)<br>• Pelvic surgeon (gynecologic oncologist, urogynecologist)<br>• Anesthesiologist (obstetric or cardiac anesthesia)<br>• Urologist<br>• Trauma or general surgeon<br>• Interventional radiologist<br>• Neonatologist |
| Intensive care unit and facilities | • Interventional radiology<br>• Surgical and medical intensive care unit (24 h intensivist availability)<br>• Neonatal intensive care unit (gestational age appropriate for neonate) |
| Blood services | • Massive transfusion capabilities<br>• Cell salvage and perfusionist<br>• Experience and access to alternative blood products<br>• Guidance of transfusion medicine specialists or blood bank pathologists |
| **Criteria for Consideration of Delivery in Accreta Center of Excellence** | |
| • Suspicion for placenta accreta on sonogram<br>• Placenta previa with abnormal ultrasound appearance<br>• Placenta previa with >3 prior cesarean deliveries<br>• History of classical cesarean delivery and anterior placentation<br>• History of endometrial ablation or pelvic irradiation<br>• Inability to adequately evaluate or exclude findings suspicious for placenta accreta in women with risk factors for placenta accreta<br>• Any other reason for suspicion for placenta accreta | |

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Many institutions have incorporated the use of endovascular catheters as a standard practice in their multidisciplinary approach to the management of patients with PAS. Current studies addressing the use of endovascular interventions for patients with PAS are inconclusive as to the necessity of stent placement. Endovascular interventions have been described for different goals (preservation of fertility, decreased maternal hemorrhage), using different modalities (balloon catheters, embolization), different vascular sites (aorta, common iliac, hypogastric, and uterine vessels), and in different settings (elective vs emergency). Future research should focus on evaluating these interventions in a more controlled fashion to determine the role, if any, of endovascular catheters in the management of PAS.

In the stable patient, and in the absence of significant vaginal bleeding or bleeding in the operative field, the time-honored principles of adequate exposure, identification of critical anatomical landmarks, meticulous dissection, and systematic control of vascular pedicles is of the utmost importance. At the same time, the surgical team should be prepared to immediately switch to a more expeditious approach aiming at removing the uterus as fast as possible in the presence of massive bleeding followed by a reassessment of the pelvic surgical field to determine any organ damage and to achieve hemostasis. The stable PAS patient will typically receive a combined spinal and epidural anesthesia. An arterial line and a central line are inserted. The patient is then placed in lithotomy position to allow for a preoperative cystoscopy and placement of ureteral catheters that will remain in this position for the rest of the procedure. Positioning of the patient in lithotomy will allow direct monitoring of any vaginal bleeding, which can go unnoticed when the patient is in supine position. It also provides better access to the pelvis for the surgical assistants, facilitate retrograde filling of the bladder, and allow placement of vaginal instruments to outline the anterior or posterior vaginal walls if needed (see **BOX 44.4**).

# BOX 44.4 STEPS IN THE PROCEDURE

## Emergent Peripartum Hysterectomy

- Anesthesia and nursing teams are promptly notified that hysterectomy is planned, and additional resources are mobilized (blood bank, surgical back up). Additional vascular access is obtained if not yet in place.
- Midline or transverse laparotomy depending on whether the source of bleeding is known and the hemodynamic status of the patient (unless occurring during a cesarean delivery).
- A self-retaining retractor is placed and the abdominal contents packed with laparotomy sponges.
- A tourniquet on the isthmus can be considered, if the uterine anatomy is preserved, to help decrease the ongoing bleeding and allow the surgery to proceed in a more controlled fashion.
- The round ligaments are divided, the retroperitoneum is opened, and the ureters are identified.
- The utero-ovarian ligaments are skeletonized and divided.
- The fallopian tubes are excised now or at the end of the procedure, depending on the acuity of the situation.
- The posterior leaf of the broad ligament is incised with the ureter under direct visualization.
- If there is any uncertainty about the superior limit of the bladder, it can be retrograde filled.
- The vesicouterine peritoneum is incised, and the bladder is mobilized to the level of the anterior vaginal wall.
- The uterine arteries are skeletonized at the level of the isthmus and divided with the ureter clearly visualized.
- The cardinal ligaments are clamped, and the tissues divided repeatedly until the level of the mid cervix (supracervical hysterectomy) or upper vagina (total hysterectomy) is reached.

- The uterus is amputated and the cervix or vaginal cuff is closed.
- Inspection of the surgical field to confirm adequate hemostasis, integrity of the bladder and ureters.

During cystoscopy, the bladder mucosa is evaluated for any gross invasion by the placental tissue, and for the presence of neovascularization and bulging into the bladder wall, which may be indirect signs of the severity of the PAS. Ureteral stents are then placed, which will allow easy and rapid identification of the ureters in case of massive hemorrhage or lateral extension of the placental mass into the parametria or pelvic sidewall. Retrospective data suggest that the placement of ureteral stents is associated with a decrease in urinary tract injury. Additional potential benefits for placement of stents include early recognition of urinary tract injury and facilitating a complex cystotomy repair by allowing facile identification of the ureteral orifices in the bladder.

Once the cystoscopy is completed, the abdomen, perineum, and vaginal are prepared and draped prior to the skin incision. It is important to be mindful that the selected skin incision should allow adequate exposure of the pelvis (including the pelvic sidewall) and lower abdomen and allow exposure of the fundal part of the uterus to allow the delivery of the fetus without disruption of the placenta. Typically, a vertical skin incision is indicated to achieve this goal. However, when the placenta is not predominantly anterior, adequate exposure may be achieved using a transverse skin incision. The authors have recently adopted a transverse skin incision approach in cases where a window on the fundal anterior part of the uterus can be identified through which a uterine incision can be initiated and then extended cephalad without disrupting the placenta, with early encouraging results.

Once the peritoneal cavity is entered, inspection of the lower segment is performed to confirm the presence and assess the severity of the PAS. An intraoperative ultrasound can be performed if needed to map the placental location. The uterine incision is started about 5 cm away from the placenta and extended in a cephalad

direction and can extend to the posterior uterine wall. In cases where the placenta is covering the entirety of the anterior uterine wall, the gravid uterus may need to be exteriorized to allow for a fundal posterior uterine incision. The uterine incision can be made in the usual fashion with the scalpel and extended bluntly or using bandage scissors. Other options have been described to minimize the blood loss from the uterine incision and include the use of a linear stapler to divide the myometrium. After the delivery of the fetus, the cord is clamped or ligated. The use of oxytocin or other uterotonics is controversial, with the concern that it might cause partial placental separation and increased bleeding. However, in the presence of an atonic uterus, there is a legitimate concern that ongoing bleeding may be taking place inside the uterine cavity in which case oxytocin use will decrease bleeding.

The lower segment of the uterus is inspected again to assess the extent of the PAS. The posterior cul-de-sac is evaluated for the presence of rectal adhesions, which may add to the complexity of surgery. The initial part of the hysterectomy involves accessing the retroperitoneal space in the pelvis and the division of the superior attachments of the uterus (round ligament and utero-ovarian ligament) and the large veins of the broad ligament on both sides. Most of the time, these steps can be achieved with minimal blood loss. The fallopian tube can be excised as well during this part of the procedure. In addition to standard suture ligation, the authors use a vessel sealing device to divide these structures.

To access the retroperitoneal space, the uterus is pulled laterally exposing the contralateral side of the pelvis. The peritoneal layer adjacent to the round ligament is incised with electrocautery, with care to limit the incision to the peritoneum only and avoid disturbing the underlying tissue, which frequently includes friable vascular tissue. This step can be facilitated by elevating the round ligament with a Babcock clamp. The peritoneal incision is then extended, and the round ligament skeletonized, divided, and suture ligated. The peritoneal incision is then extended cephalad parallel to the ovarian vessels, exposing the retroperitoneal space. Avascular windows are created in the broad ligament to isolate the utero-ovarian ligament and the large veins of the broad ligament. As these structures are

individually skeletonized, they are divided and suture ligated. The fallopian tube can be excised with a vessel sealing device. At this stage of the procedure, there is no concern for encountering the stented ureter, which can be palpated deeper in the pelvis. One point of caution is the need for gentle handling of the veins of the broad ligament. These are frequently large caliber, with fragile walls and can easily be lacerated causing the vein to retract and result in massive bleeding.

Once the division of the superior attachments of the uterus is completed, attention is directed at the identification and exposure of the ureter along its course in the pelvis. During this process, the posterior leaf of the broad ligament is divided down to the level of the ureter, which is kept under direct visualization. A more accurate evaluation can be made at this time about the lateral extent of the placenta and its relationship with the ureter. If needed, the ureter can be mobilized laterally.

At this point, attention is turned to the bladder dissection, which is the most delicate part of the procedure, and a site of potential significant blood loss and surgical complication.

Bladder adhesions due to prior cesarean deliveries and bladder wall invasion by the placenta can render the identification of the superior edge of the bladder and the vesicouterine space difficult. An attempt at mobilizing the bladder while entering the wrong plane of dissection can lead to significant bleeding by either entering the uterus and placenta or into the bladder wall. It is, therefore, imperative to be very careful at this step of the procedure; backfilling the bladder before the beginning of the dissection will assist in finding the true plane. We routinely retrograde fill the bladder with a solution of saline with methylene blue, usually using a volume of 120-180 mL. This will outline the superior limit of the bladder and indicate the proper site to start developing the vesicouterine space. We prefer using methylene blue mixed with saline instead of saline alone so that if a cystotomy occurs, leakage of blue fluid makes this obvious. Additionally, in cases of partial bladder wall involvement, the blue colored liquid present in the bladder can be seen before a cystotomy happens, signaling to the surgeon that the dissection should be redirected, and the bladder will need closer inspection

before completion of the surgery with plans to repair compromised areas.

Once the superior edge of the bladder is identified by bladder filling, the vesicouterine peritoneum is incised, and the vesicouterine space is entered. The dissection can then proceed gently using a combination of blunt dissection, electrocautery, and the vessel sealing device if vascular connections are encountered with the goal of mobilizing the bladder to the level of the anterior vaginal wall. The uterine arteries are skeletonized at the level of the isthmus and divided with the ureter under direct visualization (see **FIG. 44.7**).

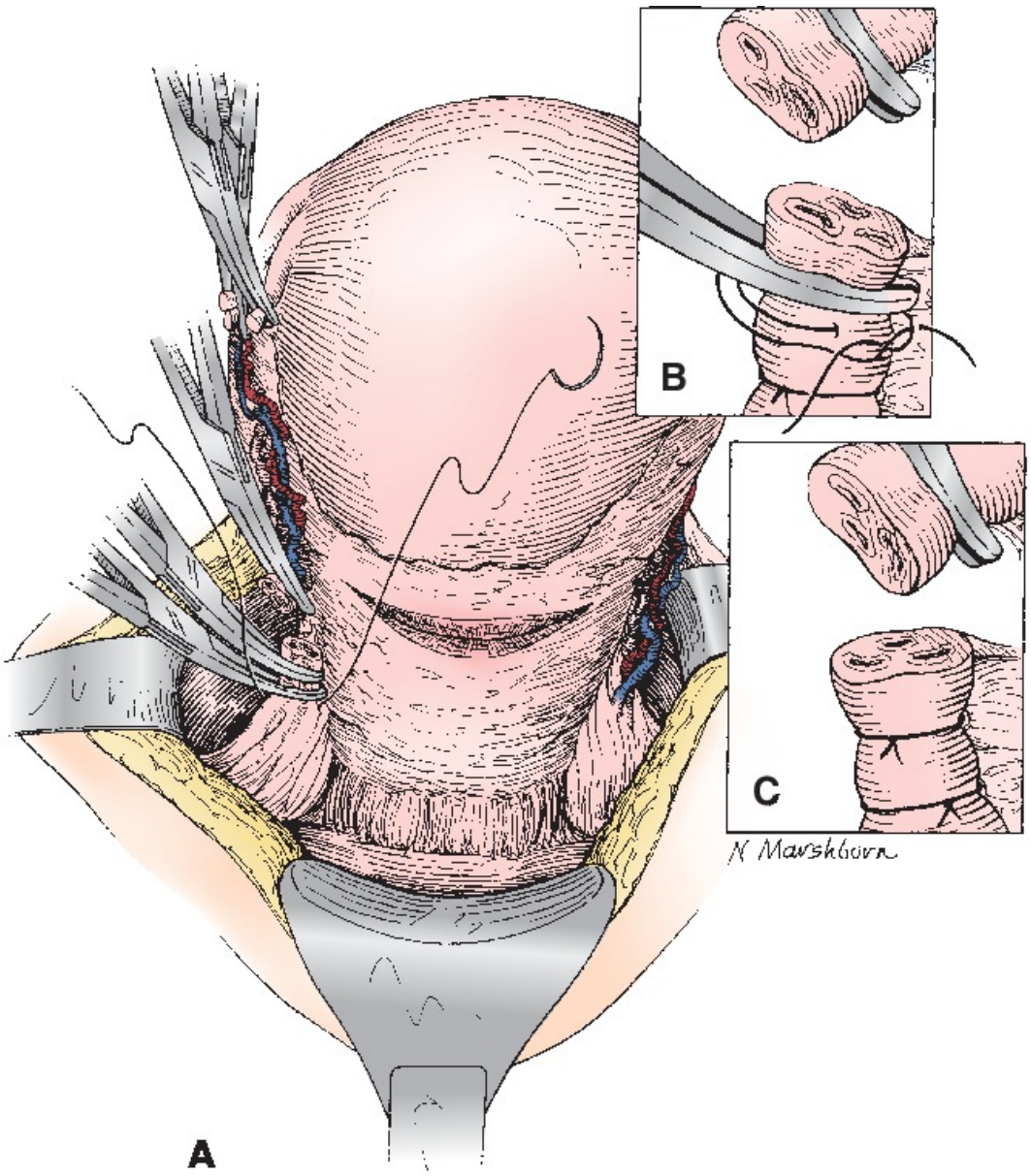


**FIGURE 44.7** **A.** The uterine artery and veins on either side are doubly clamped immediately adjacent to the uterus and divided. **B and C.** The vascular pedicle is doubly suture ligated. (Used with permission of McGraw Hill LLC from Cesarean delivery and peripartum hysterectomy. In: Cunningham

FG, Leveno KJ, Bloom SL, et al., eds. *Williams Obstetrics*. 25th ed. McGraw-Hill Education; 2018:567-590; permission conveyed through Copyright Clearance Center, Inc.)

In cases where the placenta is invading the bladder wall (partial or full thickness invasion), the vesicouterine space will be obliterated by the placental tissue. In cases of partial bladder wall invasion, the dissection will lead to areas of bladder wall thinning. If identified in a timely fashion (sometimes with the help of the fluid inside the bladder), a cystotomy can be avoided. This will remain a weakened area of the bladder wall that will need to be oversewn and covered with well-vascularized tissue. At other times, a cystotomy is unavoidable and will happen during the dissection. The cystotomy can be used to facilitate the remainder of the bladder dissection. In cases of bladder wall invasion, some surgeons will opt to perform an en bloc partial excision of the bladder wall. Care should be taken to limit the amount of bladder that is excised so as not to compromise future bladder capacity.

When the PAS extends laterally and involves the parametria, a radical or modified radical dissection of the parametria is needed. In this situation, the bladder dissection may proceed in tandem with the parametrial dissection. The parametrial tissue medial to the ureter has been invaded by the placental mass, and the ureter needs to be mobilized laterally by dividing any attachments between the ureter and the placenta. During this process, the uterine artery is divided either at its origin or at the level of the crossing of the ureter, depending on the level of lateral placental extension. Palpating the ureteral stents will assist with dissection in this space. The lateral placental attachments are completely divided, and the bladder is mobilized to the level of the anterior vaginal wall.

Significant bleeding can be encountered during dissection of the pelvic sidewall and the parametria. This is usually venous bleeding from the extensive neovascular network that has developed in this

area secondary to the placental invasion. Surgical control of the bleeding with standard measures (clips, sutures, vessel sealing device) may not be successful, and at times may cause additional trauma and bleeding. The best results are obtained by packing the bleeding area with laparotomy pads and asking a surgical assistant to maintain pressure while the surgery proceeds. Frequently, by the time the uterus is removed, adequate hemostasis has been achieved with no additional intervention needed. In the event of persistent bleeding points, these can then be controlled with additional packing and use of hemostatic agents.

The next steps are similar to those performed in a standard hysterectomy as far as dividing the cardinal and uterosacral ligaments and then coming across the upper vagina and removing the specimen. However, given that the anterior vaginal wall is often very vascular and friable in cases of PAS and in pregnancy in general, it is reasonable to consider performing a supracervical hysterectomy to limit further dissection and mobilization of the bladder. The choice, therefore, to perform a total vs a supracervical hysterectomy will depend on the amount of bleeding already encountered and the need to expedite the case, the friability of the tissues, the cervical involvement with PAS, and any prior history of cervical dysplasia.

After division of the uterine arteries, additional straight bites are taken at the level of the cardinal ligaments, and the tissues are divided and suture ligated until the level of the mid cervix (for supracervical hysterectomy) or vagina (total hysterectomy) is reached. Curved clamps are then placed across the desired level of transection and the specimen amputated. In cases where the anatomical distortion is such that it is difficult to identify the level of the anterior vaginal wall, a long packing forceps or long clamp with narrow tip can be introduced transvaginally to outline either the anterior or posterior vaginal walls and guide the dissection (see **FIG. 44.8**).

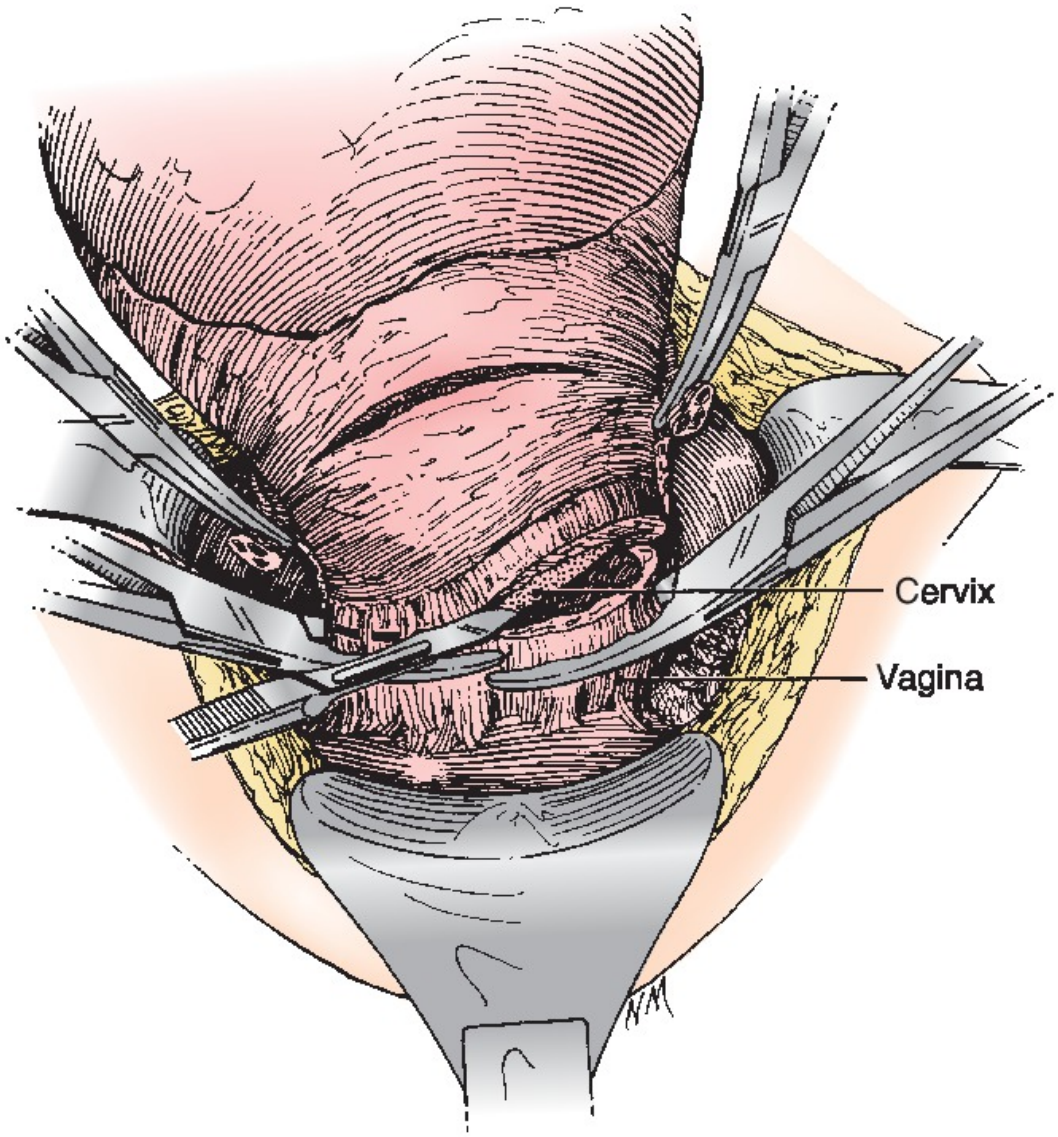


**FIGURE 44.8** A curved clamp is swung in across the lateral vaginal fornix below the level of the cervix, and the tissue is incised medially to the point of the clamp. (Used with permission of McGraw Hill LLC from Cesarean delivery and peripartum hysterectomy. In: Cunningham FG, Leveno KJ, Bloom SL, et al., eds. *Williams Obstetrics*. 25th ed. McGraw-Hill Education; 2018:567-

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Once the specimen is removed, and the vaginal cuff or cervical stump closed, a systematic inspection of the pelvic field is undertaken. The bladder and ureters are examined for the presence of any injury. The bladder should be retrograde filled one additional time to confirm the integrity of the bladder wall, identify previously unidentified cystotomy sites, and to guide the repair of areas of thin bladder wall. Depending on the concern for any vascular compromise of the bladder, an omental flap can be considered and may be sutured in place in the vesicovaginal space to bring vascular supply to the region. Irrigation of the surgical field is performed with sterile water to identify and control any bleeding points. It is not necessary to routinely leave a drain in the pelvic field, except in cases where a complex urinary reconstruction was performed in which case drainage will allow for the early detection of urine leak in the pelvis. In the absence of concern for a urinary tract injury, the ureteral stents are removed at completion of the procedure.

In the situation where diffuse bleeding from the pelvic surfaces is encountered, typically signaling the presence of a coagulopathy, packing the pelvis with laparotomy pads, and applying pressure, with or without the use of hemostatic agents, is preferred over repeated attempts at controlling multiple simultaneous bleeding areas. In the authors' experience, this provides adequate hemostatic control in most cases. Rarely, the bleeding is such that the packing cannot be removed in the operating room. In this situation, the packing is left in place, and the patient is moved to the intensive care unit for continued resuscitation with a plan to return for surgical exploration after stabilization of the patient's condition and correction of any coagulopathy.

# POSTOPERATIVE CARE

Compared to nonobstetric hysterectomy, peripartum hysterectomy is associated with higher rates of intraoperative and postoperative complications. Hemorrhage is the most common complication followed by injury to the urinary tract (bladder greater than ureters). In addition, there is an increased risk of gastrointestinal injury, vascular injury, wound complications, thromboembolic events, infectious complications, and intensive care unit admission.

During the first 24-48 hours after surgery, patients should be closely monitored for any recurrence of bleeding, while resuscitation efforts are continued until all clinical, hemodynamic, metabolic, and hematologic abnormalities have been corrected. Patients are typically admitted to the intensive care unit or a dedicated critical unit on the obstetrical floor. We typically perform a comprehensive set of laboratory studies upon arrival to the critical care unit, and this is repeated in 4-6 hours to document stability and to guide any additional resuscitative effort. Timing and frequency of additional blood testing will depend on the clinical situation. Venous thromboembolic pharmacologic prophylaxis is started 6 hours after surgery when there is no concern for ongoing bleeding or can be delayed until any bleeding concerns have resolved. Mechanical prophylaxis is usually started in the operating room and continued in the postoperative period. The Foley catheter is removed on the first postoperative day in uncomplicated cases. However, in cases of extensive bladder dissection or bladder repair (with or without cystotomy), hematuria, or need for strict monitoring of the urine output, the catheter is left *in situ* for a longer period, depending on the specific situation.

# CONCLUSION

Most obstetrical cases result in good outcomes with a healthy mother and baby. However, obstetrical complications can occur, which require skilled surgical intervention. Management of hemorrhage requires knowledge of a repertoire of procedures to minimize blood loss and a skilled multidisciplinary team that can work together to optimize care.

# KEY POINTS

- The most common cause of hemorrhage is uterine atony (70%), followed by obstetrical lacerations (20%), retained placenta (10%), and clotting factor deficiency <1%.
- A midline vertical incision will provide the quickest entry into the abdomen and the best exposure and is the preferred incision in the hemodynamically unstable patient or when the etiology of the bleeding has not been identified.
- Tying a tourniquet around the uterine isthmus is a simple maneuver that can provide temporary control of bleeding from the uterine fundus by occluding both uterine arteries at the level of the isthmus. The tourniquet effect can also be achieved by manually circling the isthmus between the thumb and index fingers of the surgeon or assistant and holding pressure.
- If the patient is stable and the broad ligament hematoma is not expanding, expectant management is appropriate. If exploration of the hematoma is warranted and there is diffuse small vessel bleeding, packing and pressure is recommended.
- A peripartum hysterectomy for uterine atony is performed in an acute setting, and some level of urgency is present. Once a decision is made to proceed with a hysterectomy for uterine atony, placing a tourniquet at the level of the isthmus after creating windows in the broad ligament can significantly decrease the amount of bleeding.
- A multidisciplinary approach to the management of patients with PAS has been shown to be associated with improved outcomes. Given the complexity of this condition and the resources required, the multidisciplinary team should include experienced pelvic surgeons, an anesthesia team with expertise in massive resuscitation, critical care specialists, and a blood bank able to manage massive transfusions.
- In the stable patient undergoing a hysterectomy for PAS, and in the absence of significant vaginal bleeding or bleeding in the operative field, the time-honored principles of adequate

exposure, identification of critical anatomical landmarks, meticulous dissection, and systematic control of vascular pedicles is of the utmost importance.

- Given that the anterior vaginal wall is often very vascular and friable in cases of PAS and in pregnancy in general, it is reasonable to consider performing a supracervical hysterectomy to limit further dissection and mobilization of the bladder.
- As in any complex pelvic surgery, identification of the ureter is a necessary step to avoid inadvertent injury. This is especially true in cases of uterine rupture, peripartum hysterectomy, or expanding broad ligament hematomas.

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# INDEX

*Note*: Page numbers followed by *b* indicate boxes, those followed by *f* indicate figures and those followed by *t* indicate tables.

## A


Abdominal compartment syndrome, 733–734
Abdominal ectopic pregnancy
    case studies, 365
    diagnosis, 364
    incidence, 364
    magnetic resonance imaging, 364–365
    management of, 365
    perinatal mortality, 364
    placenta necrosis, 365
    risk factors, 364
Abdominal enterocele repairs, 599–600
Abdominal entry, operative laparoscopy, 178–179
Abdominal exploration, 515
Abdominal hysterectomy, 491
    abdominoplasty, 430
    appendectomy, 430
    Bookwalter retractor rings, 420
    challenges
        cervical and lower uterine segment fibroid, 431
        cul-de-sac obliteration, 430–431
    complications, 433, 433*t*
    culdoplasty, 430
    examination under anesthesia, 419
    Foley catheter insertion, 419
    history, 416–417

incidence, 417
indications for, 417
newer panniculus retractors, 420
perioperative risk reduction, 432–433
    prevention of adhesion, 433
    reduce blood loss, intraoperative techniques, 433
    universal cystoscopy, 432–433
    ureteral stents, 432
postoperative care, 431–432
preoperative evaluation and management, 418–419
    abdominopelvic examination, 418
    decision-making process, 418
    pelvic imaging, 418
    physical examinations, 418
    preoperative anemia, medical management, 419
    uterine size, 418–419
risks associated with, 433–436
    biochemical markers/ovarian function and symptom questionnaires, 435
    cardiovascular disease, 435
    complications related to adhesion, 434
    cuff dehiscence, 434
    dehiscence of vaginal cuff, 434
    gastrointestinal injury, 434
    incontinence symptoms, 435
    learners and teaching effects, 435–436
    menopause, 435
    metabolic disorders, 435
    mortality, 435
    postoperative infection, 434
    postoperative neuropathy, 434
    prolapse, 435
    readmission, 435
    regret childbearing/reproductive options, 434–435

sexual function, 435
transfusion, 433
urinary tract injury, 434
self-retaining retractors, 420
supracervical (subtotal) *vs.* complete (total) hysterectomy, 430
surgical approach, 417–418
technique
absorbable suture placement, 426
amputation, 427
bladder dissection, 424, 426*b*
broad ligament incision, 423, 423*f*
cardinal ligament pedicles, 427–428, 428*b*
cervical stump closure, 427, 429*f*
closed-cuff technique, 428–429
curved Heaney clamp placement, 426*f*
figure-of-8 suture, 428
Heaney clamp advancement, 423
opening and dissecting retroperitoneum, 422, 422*b*
pedicle transection, 422, 424*f*
peritoneum opening, 425*f*
round ligament, 420, 421*f*
salpingo-oophorectomy, 423
secured infundibulopelvic ligament, 423, 423*f*
skeletonization of uterine arteries, 424–426
“snip-push-spread” technique, 423–424
supracervical hysterectomy, 427, 429*f*, 430*b*
ureter identification, 422, 422*f*
utero-ovarian pedicle isolation, 423, 424*f*
window creation using scissors, 423, 423*f*
transverse incisions, 419
trends, 417
vertical incisions, 419
Abdominal incisions
for obese patients, 158–159

transverse incisions
Cherney incision, 153–154, 154*f*
disadvantages, 151
Küstner incision, 153, 153*f*
Maylard incision, 154–156, 155*f*, 156*f*
Pfannenstiel incision, 151–152, 152*f*
space of Retzius, 153–154, 154*f*
vertical incisions
midline (median) incision, 156–158, 157*f*
paramedian incision, 158
Abdominal paravaginal repair, 591–592, 592*f*, 593*f*
Abdominal retractors, 118, 119*f*
Abdominal sacrocolpopexy (ASC), 194, 194*f*, 571
Abdominal surgery
hysterectomy
abdominoplasty, 430
appendectomy, 430
culdoplasty, 430
history, 416–417
incidence, 417
indications for, 417
perioperative risk reduction, 432–433
postoperative care, 431–432
preoperative evaluation and management, 418–419
risks associated with, 433–436
supracervical (subtotal) *vs.* complete (total) hysterectomy, 430
surgical approach, 417–418
technique, 419–429, 421*f*
trends, 417
incision techniques
for obese patients, 158–159
transverse incisions, 151–156
vertical incisions, 156–158

transverse incisions
Cherney incision, 153–154, 154*f*
disadvantages, 151
Küstner incision, 153, 153*f*
Maylard incision, 154–156, 155*f*, 156*f*
Pfannenstiel incision, 151–152, 152*f*
space of Retzius, 153–154, 154*f*
vertical incisions
midline (median) incision, 156–158, 157*f*
paramedian incision, 158
Abdominal wall
anatomy, 4*t*, 6*f*, 8*f*, 10*f*
layers, 4*t*
musculoaponeurotic layer
bladder reflection, 7
flank muscles, 4–5
peritoneum, 7
rectus abdominis and pyramidal muscles, 3–4
rectus sheath, 5–7, 6*f*
transversalis fascia, 7
umbilicus, 7
neurovascular supply
nerves of, 9–10, 10*f*
vessels of, 7–9, 8*f*, 9*f*
skin and subcutaneous tissue, 3
Abdominoplasty, 159, 430
Ablation techniques
cervical dysplasia
advantages, 459
carbon dioxide laser therapy, 460–461
cryotherapy, 459–460, 460*f*
Liger thermocoagulator, 460, 460*f*–461*f*
thermal ablation, 460, 460*f*–461*f*

endometrial ablation, hysteroscopic surgery, 276–278, 277*t*, 278*f*
vulvar, 308–310
carbon dioxide laser ablation, 309–310, 310*b*
cryotherapy, 309, 309*t*, 309*b*
Abnormal uterine bleeding, 370
ABO blood group, 729
Abortion
highly restrictive abortion laws, 299
induced (*see* Induced abortion)
surgical complications
adverse reproductive outcomes, 298
cancer, 299
cervical injury, 297
hematometra, 297
hemorrhage, 296–297
impact on mental health, 298
infection, 298
mortality, 299
retained tissue, 298
Rh sensitization, 298
uterine perforation, 297–298
Absorbable sutures
interrupted, 631, 633, 633*f*
natural, 119–120
ABTHERA system, 734
Accessory trocar placement, initial laparoscopic entry, laparoscopy, 180, 180*f*
ACE inhibitors, 54–55
ACGME data, 436, 436*f*
Acid-base disturbances, 234–237
ACT (anesthesia care team), 63, 64*t*
Activated partial thromboplastin time (APTT), 730*t*, 740–741
Active drains, 163

Active electrode, monitoring, 137–138, 138*f*
Acute appendicitis, 707–708
Acute colonic pseudo-obstruction. *See* Ogilvie syndrome
Acute pelvic pain and abnormal uterine bleeding
    adenomyosis, 89
    endometrial polyps, 88–89
    endometrioma, 89, 89*f*
    hemoperitoneum, 86, 87*f*
    hemorrhagic cyst, 86, 87*f*
    ovarian torsion, 87, 88*f*
    pelvic inflammatory disease, 88
    tubal torsion, 87
    tuboovarian abscess, 88, 88*f*
Acute Physiology and Chronic Health Evaluation (APACHE-IV), 234
Acute respiratory distress syndrome (ARDS)
    Berlin Criteria, 242, 242*t*
    management, 242
    manifestation, 241–242
    pathophysiology, 242
Acute ureteral injury, 685–686, 687*f*, 688*f*
Adenocarcinoma, 505
Adenomyomas, 747
Adenomyosis, 89
Adenosquamous carcinomas, 505
Adequate intravenous access, 805
Adhesiolysis, hysteroscopic surgery, intrauterine adhesions, 274
Adhesions
    dilatation and curettage, 257
    intrauterine adhesions, hysteroscopic surgery, 274, 275*f*
    posterior cul-de-sac dissection, 177–178
    uterine synechiae, 274
Adnexal surgery
    adnexal torsion/hemoperitoneum, 799–801, 800*f*, 801*b*
    etiology, 796

for fertility, 338–346
indications, 333
larger masses, 797
management, 796–801
minilaparotomy, 333–334
minimally invasive approach, 333–334
oophoropexy, 801
ovarian cystectomy, 797–799, 798*f*, 799*b*
ovarian diathermy, 346, 346*f*
ovarian preservation, 800–801
ovarian transposition, 343–345, 345*f*
paratubal cysts, 799, 799*f*, 800*b*
preoperative risk stratification, 796–797, 797*t*
surgical approach, 797–798
for tubal obstruction, 339–342, 340*b*, 341*f*–342*f*
tubal reanastomosis, 342–343, 343*f*–344*f*, 345*b*
ureter, 683, 683*f*
Adnexal suspension, 759, 759*f*
Adnexal torsion, management, 799–801, 800*f*, 801*b*
Adnexectomy, vaginal hysterectomy, 412
Adolescent gynecology
adnexal surgery, 796–801
adnexal torsion management, 799–801
chemoprophylaxis, 789
examination under anesthesia and vaginoscopy, 790–791, 790*t*, 791*f*, 791*b*
genital injuries management, 793–794
hymenal variant management, 791–793
insufflation, 795
laparoscopy
advantages of, 794
equipment, 794–795, 795*f*
insufflation, 795
intra-abdominal pressure, 795, 795*t*

patient positioning, 794–795
peritoneal access, 795
single-incision laparoscopic surgery, 795–796
vaginal prep, 794–795
paratubal cysts, 799, 799*f*, 800*b*, 800*f*, 801*b*
perioperative care, 789–790
preoperative counseling, 789
surgical assent and consent, 789, 790*t*
surgical planning, 789
venous thromboembolism, 789
Adrenal insufficiency, perioperative care, 55
ADS (anesthesia delivery system), 63–64, 65*f*
Adult respiratory distress syndrome (ARDS), 767
African American women, of Bartholin gland, 304
Age-associated gynecologic disorders, 43
Airway evaluation, 65–66
Alcock canal, 15, 16*f*
Alpha 2 agonists, 55
α-Adrenergic receptors, bladder anatomy, 26
Alternating current (AC)
forces, 130
radiofrequency, 130
Alternative site entry, operative laparoscopy, 177–178, 178*f*, 179*f*
American Association of Gynecologic Laparoscopists (AAGL), 376–377, 439, 451
American College of Obstetricians and Gynecologists (ACOG), 439, 451
American College of Surgeons National Surgical Quality Improvement Program, 100
American Congress of Obstetricians and Gynecologists (ACOG), 266–267, 282
American Fertility Society Müllerian anomaly classification, 772, 773*f*
Ammeter, use, 139
Anal incontinence

external anal sphincteroplasty, 661
functional anatomy
external anal sphincter (*see* External anal sphincter)
internal anal sphincter (*see* Internal anal sphincter)
Anal manometry, 588, 644
Ancillary instruments, laparoscopic surgery, 176, 176*f*
Anesthesia. *See also* Local anesthesia; Postoperative care
effects, 206, 206*t*
tubal sterilization, 317–318
Anesthesia care team (ACT), 63, 64*t*
Anesthesia delivery system (ADS), 63–64, 65*f*
Anesthesia primer
advanced monitoring, 68–69
continuum of consciousness, 64, 65*t*
depths of sedation, 65*t*
elderly patients, 67–68, 68*t*
fluid management and blood component therapy, 74–76
general anesthesia
abdominal and thoracic procedures, 71
airway management, 70, 71*f*
emergence, 72–73, 72*t*
epidural anesthesia, 73–74
induction, 69–70, 69*t*
maintenance phase, 70–72, 71*t* , 72*f*
peripheral nerve blocks, 74
postoperative recovery, 73, 73*t*
spinal anesthesia, 73
induction medications, 69–70, 70*t*
laparoscopic/robotic procedures
anesthetic perioperative complications, 77–78, 77*t*
$CO_2$ insufflation, 76–77, 76*t*
enhanced recovery methods, 78
positioning, 76
steep Trendelenburg position, 77

vascular resistance, 76–77
ventilation optimization, 77
neuromuscular blocking agents, 70, 70*t*
perioperative care models, 63
preoperative assessment and optimization, 64–68
aging, 67–68
airway evaluation, 65–66
for high-risk patients, 66–68, 67*f*
perioperative fasting guidelines, 66, 66*t*
risk assessment, 64–65, 66*t*
Angiotensin II receptor blockers, 54–55
Anion gap (AG), 234–237, 238*b*
Anorectal region in woman, 20*f*
Anterior colporrhaphy, 564, 589–591, 590*f*
Anterior colpotomy, vaginal hysterectomy, 398–400, 401*f*
Anterior compartment
colporrhaphy, 586
graft use in, colporrhaphy, 592–594, 593*f*
repair, 586, 594*b*
Anterior cul-de-sac, 181
Anterior vaginal mesh colpopexy/hysteropexy, 565*f*, 566–567
Anterior vaginal wall prolapse repair, colporrhaphy, 589–592
abdominal paravaginal repair, 591–592
anterior colporrhaphy, 589–591, 590*f*
vaginal paravaginal repair, 591
Antibiotics
dilatation and curettage, 250
first trimester induced abortion, 287
for OASIS, 673
preoperative care, 49–51
prophylactic, gynecologic patient, 49–51
pubovaginal sling, 624–625
surgical site infections, 789–790, 790*t*
Anticoagulants, venous thromboembolism

direct oral anticoagulants, 217
fondaparinux, 217
low molecular weight heparin, 217
unfractionated heparin, 217
warfarin, 217
Anticoagulation, 249
patient management, 257
Antifibrinolytic agents, for hemorrhage, 741–742
Antiplatelet therapy, 729
Antiseptic vaginal preparation, 397
Anus
anatomy, 28
perianal and vulvar lesions, 470
Aorta, 732
retroperitoneal space, anatomy, 35–41
Aortic compression, obstetrical hemorrhage, 805–806, 806*f*
Apocrine sweat glands, 14
Appendectomy, 430, 769
ovarian cancer, 538
Appendiceal endometriosis, endometriosis, 754–756, 754*f*–755*f*
Arcus tendineus fascia pelvis (ATFP), 609*f*
Argon beam coagulator, 138, 139*f*
Army-Navy retractor, 118
Arterial bleeding, hemorrhage, 730–731
Arterial ligation, 731
Ascites, 508
Aspirin, antiplatelet therapy, gynecologic patient, 54
Asthma, medications, 55
Atelectasis, 206–207, 207*t*
Atelectrauma, 242
ATFP (arcus tendineus fascia pelvis), 609*f*
Atypical hyperplasia (AH), 491
Autologous blood transfusion, hemorrhage, 738–739, 739*t*
Autonomic nerves, pelvic anatomy, 31, 38

## B


Babcock clamp, 113
Bacterial vaginosis (BV), 51, 222
Ball electrode, endometrial ablation, 278, 278*f*
Barotrauma, 242
Barrel electrode, hysteroscopy, 264*f*
Bartholin gland
    abscesses, 304–308
    anatomy, 12*f*–13*f*, 14–15
    carcinoma, 484
    carcinomas, 304
    cysts, 91, 304–308
    excision, 307–308, 307*t*, 308*f*, 309*t*
    incision and drainage using Word catheter, 305–306, 305*b*
    location, 304, 305*f*
    marsupialization, 306–307, 307*f*
    supplies for placement, 305, 305*b*
Bartholin greater vestibular gland, 14–15
Basal cell carcinoma, surgery for, 484
Base excess approach, 234
Bayonet retractor, 118
Bead chain cystourethrogram, vaginal anatomy, 23*f*
Benign ovarian masses treatment
    oophorectomy, 335–338
        laparoscopic, 336–338, 337*f*
        procedural steps, 338*b*
        vaginal incision, 336–338
    ovarian cystectomy
        containment bag usage, 335, 336*f*
        dermoid cysts, 335
        endometrioma, 335
        laparoscopic, 335, 336*f*
        meticulous hemostasis, 334–335

procedural steps, 335*b*
Benign vulvar disease management, 301
Benjamin Franklin's 18th-century experiments with electricity, 130
β-human chorionic gonadotropin (β-hCG)
ectopic pregnancy, 351–352, 352*t*
surgical resection/dissection, 362
Beta-blockers, 54
Bicornuate uterus, 86, 87*f*
Bilateral salpingectomy, tubal sterilization, 327–329, 327*b*
at cesarean section, 328
complications, 328–329
interval, 328
postpartum, 328
Bioprosthetic plugs, 646
Bipolar bowel injury, 701–702
Bipolar cautery instruments, 191
Bipolar coagulation, tubal sterilization, 322–323, 324*b*, 324*f*
Bipolar electrical circuit
definition, 132
electrosurgery, 132, 133*f*
Bipolar electrode, hysteroscopy, 261–262, 265*f*
Bipolar electrosurgery, 132, 133*f*
instruments
first generation, 138–139
second generation, 139–140
Bipolar hysteroscopic resection devices, 140–141
Bipolar method, 324*f*
BIS (bispectral index), 68–69
Bispectral index (BIS), 68–69
Bivalve technique, vaginal hysterectomy, 410, 411*f*
Bladder
anatomy, 26–27, 27*f*
dissection, 516–518, 518*f*
in gynecologic surgery

hysterectomy, 690–692, 693*b*, 693*f*
postoperative diagnosis, 694
prolapse repair, 692–693
retropubic colposuspension, 692
sling surgery, 693–694
reflection, 7
surgical anatomy, 681–682
Bladder biopsy, 643
Bladder dissection, abdominal hysterectomy, 424, 426*b*
Bladder endometriomas resection, endometriosis, 753–754, 754*f*
Bladder injury, 609
Bladder management, cervical cancer, 522
Blake drain, 163
Bland-Sutton, John, 416
Bleeding
hysteroscopic procedures, 281
persistent/excessive, 738*b*
BLEND current, 132–133
Blood conservation techniques, 75–76, 76*t*
Blood product, 739*t*
replacement, 739–741
Blood supply, genital tract, 24*f*, 26
Blood transfusion, 75–76
coagulation
autologous, 738–739, 739*t*
risks of, 737–738, 738*t*
B-Lynch suture placement, 807, 808*b*, 808*f*
Boari flap construction, 686, 688, 692*f*
Body piercing and prosthetic implants, electrosurgery, 144
Bookwalter retractor, 118
Booted stirrups, 103–104, 103*f*
Bottom-up hysterectomy, 431
Bowel clamps, 115
Bowel enterotomy, repair, 701, 701*f*

Bowel injury
midurethral slings, complications from, 616
vaginal hysterectomy complications, 413
Bowel obstruction, 544–545
bowel perforation, 707
malignant, 703–705, 704*f*, 705*f*
nonmalignant small bowel obstruction, 703, 703*f*
patient with, 710
radiation injury, 706–707, 707*f*
Bowel perforation, 707
Bowel preparation, 52
Bowel resection, 711–712, 711*f*, 713*f*, 747
Bowel surgery
consent, 708
mechanical bowel preparation, 709–710
nutritional status, 709
stoma planning, 708–709, 709*f*
Brachial plexus anatomy, upper limb
median nerve, 106
nerve roots and points of vulnerability, 106–107, 106*t*
plexus injury, 107
radial nerve, 106–107
ulnar nerve, 106
Brachial plexus injuries, 185
Breisky-Navratil retractors, 563–564, 563*f*, 582
Broad ligament, anatomy, 24–25, 24*f*, 25*f*
Bulldog clamps, 737, 742
Burch retropubic urethropexy
abdominal approach, 618–619
anatomy, 617–618
delayed complications, 620
history, 617
intraoperative complications, 620
procedure, 611*b*

Retzius space, anatomic landmarks, 608*f*, 617
surgical technique, 618–620
Burst abdomen, 167–168
Button electrode, hysteroscopy, 264*f*

## C

CAD (coronary artery disease), perioperative cardiac assessment, 45–47, 46*f*
Calcium channel blockers, 55
Camper fascia, 3, 4*t*, 14*t*
Canal of Nuck, 12
Cancer. *See Specific types of cancer*
Cancer debulking, ovarian cancer, 538
Candy cane stirrups, 104, 105*f*
Cannulation, hysteroscopy, fallopian tubes, 274–276, 276*f*
Capacitive coupling/capacitance, electrosurgery, 137, 137*f*, 138*f*
Capio device, 591
Capnothorax, 77–78
Caprini risk assessment model, 51–52, 52*t*
VTE prevention, 52*t*
Carbon dioxide laser techniques, 143
cervical dysplasia, 460–461
for vulvar lesions treatment, 309
Carbon dioxide media, hysteroscopy, 267–268
Carbonic acid-bicarbonate buffer system., 234
Carcinoma *in situ*
vaginal carcinoma, 470*t*
vulvar, 473, 473*f*
Carcinomas of Bartholin gland, 304
Cardiac disease
gynecologic complications, postoperative care, 43–44
cardiogenic shock, 205
hypertensive disease, 205
myocardial infarction, 205–206

shock, 205
Cardiac implantable electronic device (CIED), 144
adverse effects of, 145
preoperative management, 145
Cardiac testing, preoperative care, gynecologic patient, 47
chest X-ray, 47
coagulation testing, 47
complete blood count, 47
electrocardiogram, 47–48
Cardinal ligament dissection, 518–521, 519*f*, 520*f*
Cardiogenic shock, 205, 232, 233*t*
Cardiovascular disease, abdominal hysterectomy, 435
Catecholamine vasopressors, alpha 1 (α1) adrenergic receptors, 238
Catgut sutures, 119–120
Cavitation, 141
Cefazolin, 618
Center for Medicare and Medicaid Services, 64
Cervical amputation, 445, 450–451, 450*f*
Cervical and lower uterine segment fibroid, abdominal hysterectomy, 431
Cervical and uterine curettes, 115
Cervical cancer, 91–92, 92*f*. *See also* Cervical intraepithelial neoplasia (CIN)
adenocarcinoma and squamous cell carcinoma, 505
clinical presentation, 508–509, 508*f*
FIGO classification, 505, 506*f*–507*f*
histologic type of, 505
infection, 524
metastatic lymph nodes, 508–509, 509*t*
neuropathy, 524
nodal disease, impact, 508–509
pelvic exenteration
positioning and preparation, 525
procedure, 521*b*, 524–525

surgical approach, 525–526
pretreatment evaluation and staging, 509–510, 509*f*, 510*t*
procedure, 526*b*
radical hysterectomy
abdominal exploration, 515
cardinal ligament dissection, 518–521, 519*f*, 520*f*
classes of, 513, 514*t*
hypogastric artery, uterine artery, bladder and ureter dissection, 516–518, 518*f*
indications, 513, 513*t*
lymph node assessment, cervical conization, 510–511
lymphadenectomy, 522
ovarian transposition, 521–522
paravesical and pararectal space development, 515–516
positioning, 514–515
vaginal closure, 521
rectal dysfunction, 524
staging of carcinoma of cervix uteri, 507*t*
surgical management
cervical conization, 510–511, 510*f*
fertility-sparing radical abdominal trachelectomy and conization, 511–512
simple hysterectomy with lymph node assessment, 511
urologic complications
bladder management, 522
ureteral management, 522–524
venous thrombosis and pulmonary embolus, 524
Cervical conization, 510–511, 510*f*
Cervical cytology. *See* Cytology, cervical
Cervical dilation, dilatation and curettage, 252–253, 252*f*, 253*f*
Cervical dilators, 115–116
Cervical dysplasia
ablative procedures
advantages, 459

carbon dioxide laser therapy, 460–461
cryotherapy, 459–460, 460*f*
Liger thermocoagulator, 460, 460*f*–461*f*
thermal ablation, 460, 460*f*–461*f*
excisional techniques, 461–465
cold knife conization, 461–462
complications, 466–467, 466*t*
loop electrosurgical excision procedure, 463–465, 463*t*, 463*f*, 464*f*, 465*b*
obstetric outcomes, 466, 466*t*
postoperative management, 465
risk factors, 466
by human papillomavirus, 465
methods, comparison, 465–466
patients instructions, 465, 467
in pregnancy, 467
Cervical injection, SLN mapping for endometrial cancer, 497–498, 497*f*
Cervical injury, dilatation and curettage, 257
Cervical intraepithelial neoplasia (CIN), 474
Cervical pregnancy, 362–364, 363*f*
Cervicovaginal atresia, 772–774, 773*f*–774*f*, 774*b*
Cervix, diagnostic hysteroscopy, 269
Cesarean scar pregnancy, 355–357, 356*b*, 356*f*
Chemical hemostatic agents, laparoscopy, 177
Cherney incision, 153–154, 154*f*
Childbirth and Pelvic Symptoms (CAPS), 670–671
Children, gynecology
adnexal surgery, 796–801
adnexal torsion management, 799–801
chemoprophylaxis, 789
examination under anesthesia and vaginoscopy, 790–791, 790*t*, 791*f*, 791*b*
genital injuries management, 793–794

hymenal variant management, 791–793
insufflation, 795
laparoscopy
advantages of, 794
equipment, 794–795, 795*f*
insufflation, 795
intra-abdominal pressure, 795, 795*t*
patient positioning, 794–795
peritoneal access, 795
single-incision laparoscopic surgery, 795–796
vaginal prep, 794–795
paratubal cysts, 799, 799*f*, 800*b*, 800*f*, 801*b*
perioperative care, 789–790
preoperative counseling, 789
surgical assent and consent, 789, 790*t*
surgical planning, 789
venous thromboembolism, 789
*Chlamydia,* 51
Chlorhexidine vaginal prep, 589
Chromic catgut, 120
Chromopertubation, 181–182
Chronic antiplatelet therapy, patient management, 54–56
Chronic urinary retention, 631
CIED (cardiac implantable electronic device), 144
adverse effects of, 145
preoperative management, 145
Circuit, 130
Circulatory shock, vasopressors or inotropes, 237
Clear cell adenocarcinoma, 505
Clitoris
anatomy, 15–17, 16*f*
dorsal nerve, 15
lymphatic drainage, 17–18, 17*f*
Clopidogrel, 55

Closed negative pressure wound therapy, 165
Closed-cuff technique, 428–429
Closure, laparoscopy, 183–184
Clotting factors, hemorrhage, 743
$CO_2$ insufflation, 76–77, 76*t*
Coagulation
    adjuncts to control of, 734–737, 738*b*
        autologous blood transfusion, 738–739, 739*t*
        blood product replacement, 739–741, 739*t*
        electrosurgery, 734–735
        hemostatic agents, 735–736, 736*t*
        surgical clips, 734, 735*f*
        vascular clamp placement, 737, 737*f*
    blood transfusion
        autologous, 738–739, 739*t*
        risks of, 737–738, 738*t*
    minimally invasive surgery, 742
    nonsurgical interventions for, 741
        antifibrinolytic and other agents, 741–742
        embolization, 741
    postoperative management, 742–743
    risk factors for disorders, 730*t*
    surgical management, 730–734, 732*b*
        arterial bleeding, 730–731
        large vessel repair, 732–733
        packing for control of, 733–734, 733*f*, 734*f*
        vascular ligation procedures, 731–732, 731*f*
        venous bleeding, 730
    tests to, 730*t*
    tubal sterilization
        bipolar coagulation, 322–323, 324*b*, 324*f*
        unipolar coagulation, 323–324
Coagulation disorders, risk factors for, 730*t*
Coccygeus–sacrospinous ligament (CSSL) complex, 560–562, 562*f*

Cold knife conization, cervical dysplasia, 461–462
Colles fascia, 14, 14*t*
Colon obstruction, 544–545
Colonic pseudo-obstruction, 708, 708*f*
Colorectal anastomosis with circular stapler, 712–714, 715*f*, 715*b*, 716*f*
Colorectal surgery, for gastrointestinal tract complications, 724
Colostomy, 719, 721*f*, 722*b*
Colpectomy, 632–635, 634*f*
Colpocleisis, 632–635, 634*f*
    colpectomy and, 632–635, 634*f*
    complications, 636
    concomitant hysterectomy, 631
    concomitant levator myorrhaphy and perineorrhaphy, 635–636, 635*f*
    elective surgery, 629
    intraoperative cystoscopy, 636
    Le Fort colpocleisis, 631–632, 633*b*
        endometrial/cervical surveillance, 630
        interrupted absorbable sutures, 631, 633*f*
        procedure, 633, 633*b*
        vaginal epithelium removing, 631, 632*f*
        vaginal mucosa, rectangles of, 631, 632*f*
    obliterative procedures, 629–630
    pelvic organ prolapse, 630
    preoperative evaluation
        hydroureter, 630
        Le Fort colpocleisis, endometrial/cervical surveillance, 630
        occult stress incontinence, 631
        older women, pelvic organ prolapse, 630
    regret/sexual function, 637
    success/failure rates, 636–637
    vaginal obliterative procedures, 629–630
Colporrhaphy

anatomy and function
anterior compartment support, 586
Delancey's levels of support, 585–586
posterior vaginal compartment support, 586
anterior and posterior vaginal wall prolapse, 584
enterocele repair
abdominal enterocele repairs, 599–600
vaginal enterocele repairs, 599
evaluation
ancillary testing, 588
history, 587
physical examination, 587–588
initial management, 588
outcomes, 600–601
posterior, 594–599, 595*f*
postoperative care, 600
surgical management, 588–599
anterior compartment, graft use in, 592–594, 593*f*
anterior vaginal wall prolapse repair, procedures for, 589–592
midline plication/traditional posterior colporrhaphy +/- perineorrhaphy, 596*f*–597*f*, 595–598
posterior colporrhaphy, 594–599, 595*f*
posterior vaginal wall prolapse repair, procedures for, 594
sacrocolpoperineopexy, 599
site-specific repair, 598
STARR procedure, 600
transanal approach, 598
vaginal approach, graft augmented, 599
symptoms associated with vaginal wall prolapse, 584–585
Common peroneal nerve, 102–103
Complex hyperplasia (CH), 491
Complex hyperplasia with atypia (CAH), 491
Complex perineal lacerations, 688

Concomitant hysterectomy, 631
Concomitant levator myorrhaphy, 635–636, 635*f*
Congenital uterovaginal anomalies, 86
Conization, fertility-sparing radical abdominal trachelectomy and, 511–512
Connective tissue and cleavage planes, pelvis
cross section of, 29, 30*f*
cul-de-sacs, anterior and posterior, 33, 33*f*
pelvic connective tissue
urethral supports, 32–33, 32*f*
uterine ligaments, 30–31, 30*f*
vaginal attachments and extraperitoneal surgical spaces, 30*f*, 31–32, 32*f*
prevesical space, 30*f*, 33–34
rectovaginal space, 30*f*, 34
retropubic space, 30*f*, 33–34
sacrospinous ligament region, 34–35, 34*f*
vesicovaginal and vesicocervical space, 34
Constipation, 584–585
Continence pessary, 606
Continuous sinusoidal waveform (CUT), 132–133, 134*f*
Cooper ligament, 619*b*
Coring technique of morcellation, 395, 410, 411*f*
Cormack-Lehane grading system, 70, 71*f*
Coronary artery disease (CAD), perioperative cardiac assessment, 45–47, 46*f*
Corticosteroids, 55
Cotton swab test, 604*f*
Creatinine, preoperative care, gynecologic patient, 48
Critical care
acute respiratory distress syndrome
Berlin Criteria, 242, 242*t*
case study, 243, 243*f*
management, 242

manifestation, 241–242
pathophysiology, 242
intravenous volume resuscitation
electrolyte replacement, 240–241
fluid choice, 240
fluid status, 239–240
oliguria, 240
with postoperative hemorrhage, 243–244
sepsis, 243–244, 243*f*
shock
acid-base disturbances, 234–237
cardiogenic shock, 232, 233*t*
definition, 232
distributive shock, 232, 233*t*
hemodynamic monitoring, 234, 235*t*–237*t*
hypovolemic shock, 232, 233*t*
management of, 233, 233*b*
obstructive shock, 232–233, 233*t*
oxidative stress and cellular injury, 232
vasopressors or inotropes, 237–238, 239*t*
Crocodile-jawed forceps, hysteroscopy, 264*f*
Crohn disease, 662–663
CD–related RVFs, 644
Crura, 15, 19
Cryotherapy
cervical cancer management, 459–460
cervical intraepithelial neoplasia, 459–460, 460*f*
vulvar lesion, 309, 309*t*, 309*b*
CSSL (coccygeus-sacrospinous ligament) complex, 560–562, 562*f*
CT cystogram, 537
Cuff dehiscence, abdominal hysterectomy, 434
Cul-de-sac disease, 536–537
obliteration, abdominal hysterectomy, 430–431
pelvic

anterior and posterior, 33, 33*f*
rectovaginal space, 29, 30*f*
retropubic/prevesical space, 30*f*, 33–34
sacrospinous ligament and greater sciatic foramen, 34–35, 34*f*
resection of, endometriosis, 750–752, 751*f*, 752*f*
vesicovaginal and vesicocervical space, 34
Culdoplasty, 430
Current (power) density
definition, 130
electrosurgery, 132, 133*f*
Cutting needle, hysteroscopy, 261, 264*f*
Cyst rupture, 86, 87*f*
Cystoscopy, 558, 590, 603, 610*f*, 812–813
vaginal hysterectomy, 407
Cystotomy, midurethral slings, complications from, 614–615
Cystourethroscopy, 643
Cytology, cervical, 250*t*

## D

daVinci Surgical System
components
EndoWrist instruments, 190–191, 190*f*
patient-side cart, 190, 190*f*
surgeon console, 189, 190*f*
vision system, 191
instrument selection, 190–191
da Vinci Xi robotic platform, 495
Davydov neovagina procedure, 779, 782*f*
De novo dyspareunia, 616
De novo urinary urgency, 616
Deaver retractors, 118
Debulking myomectomy, 431
Decision-making, 729

Deep incisional surgical site infections, 227, 227*b*
Defecography, 588
Dehiscence, wound, 151, 167–169
and evisceration, 168
incision types, 168
management, 168–169
pathogenesis, 168
Delancey's levels of support, colporrhaphy, 585–586
Delirium, postoperative, 204–205
diagnosis, 204–205
patient evaluation, 204–205
risks factors, 204, 204*t*
treatment, 205
Delivery
cesarean, 317
bilateral salpingectomy, 328
vaginal
minilaparotomy, 318
postpartum sterilization after, 317
uterine perforation, 297–298
Denitrogenation, 70
Denonvilliers fascia, 31, 586
Dermoid cysts, 89–90, 90*f*
DES (diethylstilbestrol), 505
Desiccation, definition, 133–134
Desmopressin, 742
Diabetes, preoperative care, gynecologic patient, 44
Diagnostic laparoscopy, 181–182, 182*t*
Diagnostic procedures, hysteroscopy, 269, 270*b*, 270*f*
Diagnostic sheath, hysteroscopy, 260–263, 263*f*, 264*f*, 265*f*
Dialysis, gynecologic disorders, 45
Diaphragm tumor resection, ovarian cancer, 539–540
Diet, 202
Diethylstilbestrol (DES), 505

Difficult anterior colpotomy, vaginal hysterectomy, 407–408
blunt instrument, 408
cervix and uterus during dissection, 408, 408*f*
dissection beneath cesarean section, 407–408, 408*f*
hysterectomy specimen, 408, 408*f*
retrograde filling bladder, 408
sharp dissection, 408
Digoxin, 55
Dilatation and curettage (D&C)
anticoagulated patients management, 257
cervical dilation, 252–253, 252*f*, 253*f*
contraindications, 249
curettage, 253–254, 254*f*–255*f*
delayed complications
hemorrhage, 257
infection, 257
intrauterine adhesions, 257
endometrial biopsy, 254–255, 255*f*
EndoSampler, 255*f*
Flexisound, 252, 252*f*
Handshake grip, 254*f*
Hegar dilators, 252–253, 253*f*
hysteroscopy, role of, 255–256
imaging, role of, 250–251
immediate complications
cervical injury, 257
hemorrhage, 256
uterine perforation, 256, 256*b*
local anesthesia, 251
Os Finder, 252*f*
patient positioning, 251
pelvic examination, 252
Pipelle, 255*f*
Polyp forceps, 255*f*

Pratt dilators, 253*f*
preoperative counseling, 250
preoperative evaluation
history, 249–250
physical examination, 250
preparation and visualization, 252
prophylactic antibiotics, 250
regional/general anesthesia, 251
Sims uterine curettes, 254*f*–255*f*
single-tooth tenaculum, 252, 252*f*
therapeutic indications, 249, 250*t*
Dilute vasopressin solution, 589–590
Direct coupling, electrosurgery, 136–137
Dispersive electrodes (return pads), 131–132, 132*f*
Dissection techniques, 122–123
Disseminated intravascular coagulation (DIC), 743
Distending media, hysteroscopy
gaseous media, 267–268
operative procedures, 269–271, 271*b*
Distributive shock, 232, 233*t*
Diuretics, 55
Docking Si and Xi platforms, 191–192
Double-barreled wet colostomy, 526
Doxycycline, 764–765
Dwell time, 142

## E

EAS (external anal sphincter ), 644–646, 661, 663
Eccrine sweat glands, vulvar region, 14
Ectopic pregnancy
abdominal ectopic pregnancy, 364–365
cervical pregnancy, 362–364, 363*f*
cesarean scar pregnancy, 355–357, 356*b*, 356*f*
diagnosis

asymptomatic women, screening for, 350
diagnostic aspiration, 352–353, 352*f*
diagnostic laparoscopy, 353
serum hCG testing, 351–352, 352*t*
transvaginal ultrasonography, 350, 351*f*
heterotopic pregnancy, 366–367, 366*f*
interstitial pregnancy
*vs.* angular, 357–358
asymptomatic, 357
cornual pregnancy and, 357–358
diagnosis, 357
morbidity and mortality, 357
persistence, 360
risk factors, 357
surgical treatment, 357–360, 361*f*
ultrasound imaging, 357, 358*f*
in IUD users, 349
maternal mortality from, 349
ovarian pregnancy, 360–362, 362*b*, 362*f*
postoperative care, 367
rates of, 349
risk factors, 349
rudimentary horn pregnancy, 365–366
sites of, 349, 350*f*
tubal pregnancy, 353–355, 355*b*
Edge resection of labia, 313, 313*f*–314*f*
EEA (end-to-end anastomosis) sizer, 538
Elderly patients, anesthetic medications, 67–68, 68*t*
Electricity
flow of, 130
in medicine, 130
use of, 130
Electrocardiogram, preoperative care, gynecologic patient, 47–48
Electrocautery, 129–130

Electrolyte imbalances
calcium, 241
magnesium, 241
phosphate, 241
potassium, 241
sodium, 240–241
Electrolyte replacement, 240–241
Electrolytes, 202–203
abnormalities, preoperative care, gynecologic patient, 48
Electrosurgery
applications
bipolar endometrial ablation, 140–141
operative hysteroscopy, 140–141
body piercing and prosthetic implants, 144
circuits
continuous *vs.* interrupted waveforms, 132–134, 134*t*
monopolar *vs.* bipolar circuits, 132, 133*f*
and tissue effects, 134–136, 134*t*
complications, 282
definition, 130
development of, 129–130
hazards of, 145
history of, 129–130
implantable devices, 144–145
patient safety
active electrode monitoring, 137–138, 138*f*
bipolar instruments, 138–140
capacitive coupling, 137, 137*f*, 138*f*
direct coupling, 136–137
insulation failure, 137
open activation, 136
pregnancy and, 144
principles of, 130–131, 131*f*
Electrosurgery, for hemorrhage, 734–735

Electrosurgical circuits
continuous *vs.* interrupted waveforms, 132–134, 134*t*
monopolar *vs.* bipolar circuits, 132, 133*f*
and tissue effects, 134–136, 134*t*
Electrosurgical device (ESU), 536–537
Electrosurgical units (generators), 131–132, 131*f*
"BLEND" mode, 132–133
dispersive electrodes (return pads), 131–132, 132*f*
output, 131, 131*f*
Elevate and incise technique, 123, 123*f*
Embolization, 741
Emergent peripartum hysterectomy, 812, 813*b*
Encision (formerly ElectroShield) system, 137–138, 138*f*
Endoanal ultrasound, RVF, 644
Endometrial ablation
efficacy and complications, 277–278
first-generation, 276
hysteroscopic technique, 278, 278*f*
sampling, 276
second-generation, 276, 277*t*
Endometrial biopsy, dilatation and curettage, 254–255, 255*f*
Endometrial cancer, 92–93, 93*f*
endometrial hyperplasia
characteristics, 491
diagnosis, 491
hysterectomy, 491
oophorectomy, 492
progestin therapy, 491
risk of malignancy, 491
two-tier system, 491
endometrioid histology, 488
FIGO surgical staging system, 489
corpus uteri, 489, 489*t*
pattern of spread, 489–490

histologies, 489, 490*t*
Lynch syndrome, 501–502, 502*t*
management, 500–501
mortality rate, 488
obesity-related disorders, 500
ovarian preservation, 501
prognostic features, 490–491, 490*t*
sentinel lymph node mapping, 496–500
accurate detection of, 497
distribution, 498, 498*f*
dye injection method, 497–498
injection, 497–498, 497*f*
lymphatic assessment algorithm, 499, 499*f*
pathology, 499–500
steps, 497*b*
surgical approach, 498–499
subgroups, 488
surgery for, 492–500
hysterectomy, 493
lymphadenectomy, 494–495, 494*f*
minimally invasive hysterectomy, 495–496, 497*b*
minimally invasive lymphadenectomy, 496, 497*b*
perioperative assessment and preparation, 492–493
peritoneal washings, 492
sentinel lymph node mapping, 496–500, 497*f*, 498*f*, 499*f*
staging, 492
type II tumors, 501
uterine sarcomas, 501
undiagnosed, 502–503
Endometrial hyperplasia
characteristics, 491
diagnosis, 491
hysterectomy, 491
oophorectomy, 492

progestin therapy, 491
risk of malignancy, 491
two-tier system, 491
Endometrial intraepithelial neoplasia (EIN), 491
hormonal therapy, 491, 492*t*
Endometrial polyps, 88–89
Endometrial sampling, indications, 250*t*
Endometrial/cervical surveillance, Le Fort colpocleisis, 630
Endometrioma, 89, 89*f*
Endometriosis
ablation/fulguration, 748
laparoscopic evaluation, 748
pain and fertility outcomes, 748
pathologic diagnosis, 748
surgery, robotics in, 195
surgical treatment
abdominal wall endometriosis, 756–757, 757*b*
“add-back” therapy, 749, 749*t*
appendiceal endometriosis, 754–756, 754*f*–755*f*
bladder endometriomas resection, 753–754, 754*f*
cul-de-sac lesions resection of, 750–752, 751*f*, 752*f*
extirpative resection, 753
extrapelvic endometriosis, 757
implants resection of, 750, 750*f*
ovarian endometrioma, 752, 753*f*
presacral neurectomy, 756, 756*f*, 757*b*
rectal endometriosis, 752–753
Endopelvic fascia, 551, 586
definition, 29, 33
Endotracheal intubation and ventilatory support, 208
Endovaginal ultrasonography, tubal ectopic pregnancy, 350, 351*f*
EndoWrist instruments, daVinci Surgical System, 190–191, 190*f*
End-to-end anastomosis (EEA), 472, 538, 572, 706
End-to-end repair, 672, 672*f*, 673*b*

Enhanced recovery after surgery (ERAS), 67–68, 78, 589
guidelines, gynecologic patient, 56, 57*t*–58*t*
pathway, 723
Enhanced recovery after surgery (ERAS) protocols, 580
EnSeal Laparoscopic Vessel Fusion System, electrosurgery, 140
EnSeal technology, bipolar electrosurgical instruments, 140
Enterocele repair, 564
anatomy and function
anterior compartment support, 586
Delancey's levels of support, 585–586
posterior vaginal compartment support, 586
anterior and posterior vaginal wall prolapse, 584
colporrhaphy
abdominal enterocele repairs, 599–600
vaginal enterocele repairs, 599
enterocele repair
abdominal enterocele repairs, 599–600
vaginal enterocele repairs, 599
evaluation
ancillary testing, 588
history, 587
physical examination, 587–588
initial management, 588
outcomes, 600–601
postoperative care, 600
surgical management, 588–599
anterior compartment, graft use in, 592–594, 593*f*
anterior vaginal wall prolapse repair, procedures for, 589–592
midline plication/traditional posterior colporrhaphy +/- perineorrhaphy, 596*f*–597*f*, 595–598
posterior colporrhaphy, 594–599, 595*f*
posterior vaginal wall prolapse repair, procedures for, 594
sacrocolpoperineopexy, 599

site-specific repair, 598
STARR procedure, 600
transanal approach, 598
vaginal approach, graft augmented, 599
symptoms associated with vaginal wall prolapse, 584–585
Enterolysis, 699–700
Enucleation of intramural myoma, 193–194, 194*f*
Epidural anesthesia, 73–74
Episioproctotomy, 663
Episiotomy, 649–650
complications
extension, 660*f*
hematoma, 659
infection and dehiscence, 647
complications of, 670
dehiscence, 670
extension, 670
hematoma, 670
infection, 670
incidence, 640–641, 668
indications, 662, 668
mediolateral episiotomy, 668–669, 669*f*
midline episiotomy, 640–641, 668–669, 669*f*
OASIS, 670–674
antibiotics, 673
delayed repair of, 674
end-to-end repair, 672, 672*f*, 673*b*
fecal incontinence, 673–674, 674*t*
follow-up, 673
incidence, 670–671
infection and wound breakdown, 673
overlapping repair, 672, 673*f*
perineal care, 673
postpartum management, 673

primary repair technique, 671*f*
rectovaginal fistula, 674
risk factors, 670–671
primary episiotomy repair, 642, 669, 670*b*
Equipment failure, operative hysteroscopy complications, 282
ERAS (enhanced recovery after surgery), 67–68, 78
guidelines, gynecologic patient, 56, 57*t*–58*t*
pathway, 723
Erectile structures, autonomic innervation, 17
ESU (electrosurgical device), 536–537
European Society of Hysteroscopy (ESH), 376, 376*t*
Evisceration, wound, 168
secondary closure, 169*f*
Examination under anesthesia (EUA), with vaginoscopy, 790–791, 790*t*, 791*f*, 791*b*
Excision techniques, marsupialization, Bartholin duct cysts, 306–307, 307*f*
Excisional biopsy, 303–304, 304*f*
Excisional procedures, cervical dysplasia, 461–465
cold knife conization
advantage, 461
under anesthesia, 461
cost, 461
endocervical curetting, 461–462
incision, 461–462
steps, 462, 463*b*
Sturmdorf technique, mattress suture in, 462, 462*f*
complications, 466–467, 466*t*
loop electrosurgical excision procedure, 463–465, 463*t*, 463*f*, 464*f*, 465*b*
obstetric outcomes, 466, 466*t*
postoperative management, 465
risk factors, 466
ExCITE technique

myoma extraction, 193, 193*f*
set up, 193*f*
Exercise capacity, 45
Exercise stress test, 43–44
External anal sphincter (EAS), 644–646, 661, 663
External genitalia, 11–12, 12*f*–13*f*
Extirpative resection, endometriosis, 753

## F

Fallopian tubes
anatomy, 24*f*
cannulation, hysteroscopy, 274–276, 276*f*
distal end of, 24
masses of, 333
Faradic effect, 130, 144
Fascial closure, 193
devices, operative laparoscopy, 180, 180*f*
Fascial dehiscence, 151
Fecal diversion, surgical repair, RVFs, 649
Fecal incontinence, 673–674, 674*t*
Female pelvic medicine and reconstructive surgery (FPMRS), 599
Femoral artery, 741*f*
Femoral nerve injury, 10–11, 11*f*, 102, 185–186
Femoral triangle, lymphatic drainage of, 17–18, 17*f*
Femoral vein, vulva anatomy, 18
Fertility-preserving cystectomy, 797–798
Fertility-sparing radical abdominal trachelectomy, 511–512
Fertility-sparing surgery, ovarian cancer, 534–535, 534*t*
Fibers of Luschka, 23
Fibrin glue instillation, anal and rectal vaginal fistulas, 646
Fibroids, 89–90, 90*f*
FIGO. *See* International Federation of Gynecology and Obstetrics (FIGO)
FIGO surgical staging system

endometrial cancer, 489
corpus uteri, 489, 489*t*
pattern of spread, 489–490
Fimbrioplasty, 341*f*, 342*f*
Fire hazards, electrosurgery, 145
First trimester induced abortion
epidemiology, 286
legal framework, 286
medication abortion, 291–292
preoperative counseling, 286–287
preoperative evaluation, 287
prophylactic medications, 287
surgical uterine vacuum aspiration, 287–291, 287*t*, 288*f*, 289*f*, 290*f*, 291*f*
assessing completion of procedure, 290–291, 291*f*
cervical preparation, 287
electric vacuum aspiration, 290
manual vacuum aspiration, 289–290, 290*f*
mechanical cervical dilation, 288–289, 289*f*
pain control, 287–288
paracervical block, 288, 288*f*
tenaculum placement, 288, 289*f*
ultrasound imaging, 288
uterine vacuum aspiration, 289–290, 290*b*, 290*f*
First trimester miscarriage
definition, 284
diagnosis, 285
epidemiology
demographic factors, 284
environmental factors, 284
maternal health conditions, 284
risk factor, 284
management
clinical, 285

expectant, 285
medical, 285
preoperative counseling, 285
surgical, 286
Fistulae management, 705–706
Fixed retractors, 118, 119*f*
Flank muscles, 4–5
Flexible hysteroscope, design and instrumentation, 263, 266*f*
FlexVR training platform, 193*f*
Fluid choice, 240
Fluid management and blood component therapy, anesthesia primer
intraoperative blood loss, 75–76
perioperative fluid administration, 74–75, 75*t*
Fluid overload, operative hysteroscopy complications, 280–281
Fluid status, 239–240
Fluids, 203, 203*t*
Fogarty arterial embolectomy catheter, 649–650
Foley catheter, 600, 649–650
Forceps, hysteroscopy instrumentation, 261, 264*f*
Fossa ovalis, lymph nodes, 18
Four-arm robotic trocar placement, 192*f*
Frailty, 47
Frankenhäuser ganglion, 26, 38
Fulguration, 134–135
Functional capacity measurement, 45–47, 45*t*

## G

GA. *See* General anesthesia (GA)
Gartner duct cysts, 91
Gas embolism, operative hysteroscopy complications, 282
Gastrointestinal injury, abdominal hysterectomy, 434
Gastrointestinal tract complications, 185
acute appendicitis, 707–708
anatomy

large intestine, 697–699, 698*f*–699*f*
small intestine, 697, 698*f*
stomach, 696–697, 697*f*
bowel obstruction, management
bowel perforation, 707
malignant, 703–705, 704*f*, 705*f*
nonmalignant small bowel obstruction, 703, 703*f*
patient with, 710
radiation injury, 706–707, 707*f*
bowel surgery
consent, 708
mechanical bowel preparation, 709–710
nutritional status, 709
stoma planning, 708–709, 709*f*
fistulae, management, 705–706
gynecology, postoperative care
antiemetic medications, 209, 209*t*
postoperative ileus, 209–210
postoperative nausea and vomiting, 209, 209*t*
small bowel obstruction, 210–211, 210*t*
total parenteral nutrition, 211–212
inadvertent bowel injury management, 701–702
bipolar bowel injury, 701–702
monopolar bowel injury, 701–702
repair bowel enterotomy, 701, 701*f*
thermal injury, 701–702
Ogilvie syndrome, 708, 708*f*
postoperative care and complications
colorectal surgery, 724
intestinal stomas, 724–726, 725*f*
ostomy closure, 726
small bowel anastomosis, 723–724
wound management, 723
procedures

appendectomy, 710, 711*b*
bowel resection, 711–712, 711*f*, 713*f*
colorectal anastomosis with circular stapler, 712–714, 715*f*, 715*b*, 716*f*
colostomy, 719, 721*f*, 722*b*
end colostomy takedown, 722, 722*b*
hand-sewn anastomosis, 715–716, 717*f*, 717*b*, 718*f*, 719*b*
ileostomy, 717–719, 720*f*, 721*b*
loop ostomy closure, 719–721, 722*b*, 722*f*
rectosigmoid colectomy, 712, 714*b*, 714*f*
Gastrostomy tube placement, ovarian cancer, 545
General anesthesia (GA)
abdominal and thoracic procedures, 71
airway management, 70, 71*f*
emergence, 72–73, 72*t*
epidural anesthesia, 73–74
induction, 69–70, 69*t*
maintenance phase, 70–72, 71*t* , 72*f*
peripheral nerve blocks, 74
postoperative recovery, 73, 73*t*
spinal anesthesia, 73
Genital injuries
accidental *vs.* nonaccidental, 793, 794*t*
management, 793–794, 794*b*
nonhymenal, 794
repair of, 794
surgical repair, 794
wound closure indications, 794
Genital tract, blood supply and lymphatics, 24*f*, 26
Genitalia, external anatomy, 470*f*
Genitofemoral nerve, 10
Geriatric patients, laparoscopy, 187–188
Germ-cell tumors, 545
Glassy cell adenocarcinoma, 505

Glycemic control, gynecologic patient, 51
Glycine, low-viscosity solution, hysteroscopy, 266*t*, 267
Gonadotropin-releasing hormone (GnRH) analogues, 419
*Gonorrhea,* 51
Gore-tex, 620
Gracilis muscle interposition, 665–666
Graft, techniques and materials. *See Specific flap techniques*
Gynecologic surgery. *See* Incision techniques; Postoperative care; Preoperative care, gynecologic patient; Wound healing
Gynecology
    cancers, radiology primer
        cervical cancer, 91–92, 92*f*
        endometrial and uterine cancers, 92–93, 93*f*
        ovarian cancer, 93–94, 94*f*
        vaginal and vulvar cancer, 93
    immediate postoperative care
        aggressive pulmonary expansion, 201
        diet, 202
        early ambulation, 201
        fluids and electrolytes, 202–203, 203*t*
        foley management, 204
        intraoperative anesthesia record, 201
        pain control, 201–202, 203*t*
    intermediate postoperative care
        cardiac complications, 205–206
        gastrointestinal complications, 209–212
        postoperative delirium, 204–205
        postoperative transfusion, 213–215
        pulmonary complications, 206–209
    renal complications and electrolyte imbalances, 212–213
    venous thromboembolism, 215–218
    wound care, 215

## H

H2 blockers, 55
Halban culdoplasty, 600
Handheld retractors, 118, 118*f*
Hand-sewn anastomosis, 715–716, 717*f*, 717*b*, 718*f*, 719*b*
HAP (hospital-acquired pneumonia)
    algorithm, 207, 208*f*
    treatment, 207, 208*t*
Harmonic scalpel, 117–118
Hasson open technique , initial laparoscopic entry, laparoscopy, 178–179, 179*f*
Heaney/Heaney-Ballentine clamps, 114–115
Heat (thermal energy), 141
Hematocrit, preoperative care, gynecologic patient, 47
Hematoma, 659
    complications of episiotomy, 670
Hemodynamic monitoring, 234, 235*t*–237*t*
Hemoperitoneum, 86, 87*f*
Hemorrhage, 53
    abortion, surgical complications, 296–297
    adjuncts to control of, 734–737, 738*b*
        autologous blood transfusion, 738–739, 739*t*
        blood product replacement, 739–741, 739*t*
        electrosurgery, 734–735
        hemostatic agents, 735–736, 736*t*
        surgical clips, 734, 735*f*
        vascular clamp placement, 737, 737*f*
    definition of, 729
    dilatation and curettage, 256
    minimally invasive surgery, 742
    nonsurgical interventions for, 741
        antifibrinolytic and other agents, 741–742
        embolization, 741
    postoperative management, 742–743
    surgical management, 730–734, 732*b*

arterial bleeding, 730–731
large vessel repair, 732–733
packing for control of, 733–734, 733*f*, 734*f*
vascular ligation procedures, 731–732, 731*f*
venous bleeding, 730
surgical preparation, 729–730
vasculature, 741
Hemorrhage injury, vaginal hysterectomy complications, 413
Hemorrhagic cyst, 86, 87*f*
Hemorrhagic shock. *See also* Hypovolemic shock
treatment, in obstetric and gynecologic patient, 214–215
Hemostasis, 147–148, 631
clamps, 113
Hemostatic agents, 735–736, 736*t*, 806–807, 810, 815
hemorrhage, 735–736, 736*t*
laparoscopy, 177
Hemostatic clamps, 113
Hepatic function, 743
Herbal and dietary supplements, gynecologic patient, 56
Hertz (Hz), 131
Heterotopic pregnancy, 366–367, 366*f*
High rectovaginal fistula repair, 657, 658*f*
High-fidelity virtual reality robotic simulator, 192
High-viscosity liquid media, hysteroscopy, 266*t*, 267
Hormonal therapy, for endometrial intraepithelial neoplasia, 491, 492*t*
Hormone replacement therapy, 55
Hospital-acquired pneumonia (HAP)
algorithm, 207, 208*f*
treatment, 207, 208*t*
Hounsfield unit (HU), 83
Human papillomavirus (HPV), 469
Hydrodissection, 124
Hydroureter, 630

Hymenal ring, 14, 17, 19, 32
Hymenal variants
complete imperforate hymen with bulging hymenal membrane, 792, 792*f*
definitive surgical correction, 792
imperforate hymen, 791–793
management, 791–793, 792*f*
maternal estrogen effect, 791–792
septate hymenal variants, 793, 793*f*
Hymenectomy, 792–793
Hyperkalemia, 213
Hypernatremia, 213
Hyperoxia, 242
Hypertension, 205
gynecologic disorders, 44
Hyperthermic intraperitoneal chemotherapy, ovarian cancer, 543–544
Hypogastric artery
dissection, 516–518, 518*f*
ligation, 125–126, 808–809, 809*f*
Hypogastric artery ligation, 731–732, 731*f*, 732*b*, 741
Hypogastric plexus
inferior, 17, 27, 38
superior, 37*f*, 38
Hypokalemia, 213
Hypolipidemic non-statin drugs, 55
Hypothermia during laparoscopic pelvic surgery, 78
Hypovolemic shock, 232, 233*t*
Hyskon liquid media, hysteroscopy, 266*t*, 267
Hysterectomy, 491–492, 578, 731
bladder, 690–692, 693*b*, 693*f*
clamps, 114, 115*f*
endometrial hyperplasia, 491
*vs.* hysteropexy procedures, 568

for placenta accreta spectrum, 811–816, 812*t*, 813*b*, 814*f*, 815*f*
ureter, 682–683, 682*f*
for uterine atony, 810–811, 811*b*
*vs.* uterine preservation (hysteropexy), 552–553
Hysterosalpingogram (HSG), 339
Hysteroscopic myomectomy, 374–382
abnormal uterine bleeding, 374
complications, 382
concerning symptoms after, 382*t*
fluid management with monopolar hysteroscopic, 380
general principles, 377–378
gynecologic surgical practice, 374–375
instrumentation, 378
operative approach with electrosurgical devices
assembled bipolar resectoscope, 378, 379*f*
automatic fluid management system, 379–380
bipolar generator with bipolar hysteroscopes, 378, 378*f*–379*f*
bipolar loops, 378–379, 379*f*
electric energy, 379
nonionic fluid media, 380
pseudocapsule, 379
saline infusion sonogram, 380
standard instrument, 378, 379*f*
wire loop, 378
postoperative recommendations, 381
preparation
ESH classification system, 376, 376*t*
saline infusion sonogram, 376, 376*f*–377*f*
procedural steps, 375*b*
tissue retrieval systems, 381
vaporization, 380–381
Hysteroscopic resection of uterine septum, 784, 785*b*, 785*f*
Hysteroscopy, 255–256

complications, 280–282
equipment failure, 282
fluid overload, 280–281
gas embolism, of
infection, 282
intraoperative and postoperative bleeding, 281
poor visualization of operative field, 281
uterine perforation, 280, 281*f*
computer-based models, 259, 260*f*
cutting loop electrode, 261, 264*f*
diagnostic and operative sheaths, 260–263, 263*f*, 264*f*, 265*f*
diagnostic techniques, 269, 270*b*, 270*f*
distending media
gaseous media, 267–268
liquid media, 267
low-viscosity, 267
operative field, 265–266
types, 266, 266*t*
electrosurgical devices and lasers, 271
endometrial ablation, 277*t*, 278, 278*f*
endoscopic microchip camera, 260
fallopian tube cannulation, 274–276, 276*f*
flexible hysteroscope, 263, 266*f*
forceps, 261, 264*f*
historical background, 259
hysteroscopic procedures, 271–280
intrauterine adhesions, 274, 275*f*
intrauterine device removal, 279
light generators, 260
monopolar electrodes, 261
morcellators setup, 262–263, 265*f*
myomectomy techniques, 271–272, 271*b*
office, 268–269
postoperative interventions, 282

preoperative considerations
cervical ripening, 268
contraindications, 268
misoprostol, 268
risk factors, 268
vasopressin injection, 268
resectoscope, 261, 263*f*
septate uterus, 273–274, 273*f*
shaving technique, 272, 272*f*
sterilization, 276
techniques
ball ablation, 140
complications, 140
endometrial loop resection, 140
telescopes, 259–260, 261*f*, 262*f*
tubal occlusion, 326–327
uterine C-section scar defect, 279–280, 279*f*
uterine polyps, 270*f*, 272–273
uterine synechiae, 274
Versapoint bipolar electrode, 261–262, 265*f*


## I


IAS (internal anal sphincter), 660*f*
Idarucizumab, 742
Ileal interposition, 686, 692*f*
Ileostomy, 717–719, 720*f*, 721*b*
Ileus, postoperative
abdominal x-ray imaging, 210
early ambulation, 209
gum chewing, 209–210
mechanism of, 209
and postoperative obstruction, differential diagnosis, 210*t*
treatment, 210
Iliac vessels

external, 35, 39
internal, 15, 35–36, 39–40
superficial circumflex, 8, 18
Iliohypogastric nerves, 101, 151
Ilioinguinal nerves, 101, 151
Iliopectineal ligament, 617
Illegal abortion. *See* Abortion
Imaging assessment. *See specific imaging techniques*
Impedance (ohms), 130–131
Implantable cardiac defibrillator (ICD) therapy, 145
Implantable devices, electrosurgery, 144–145
Implants resection, endometriosis, 750, 750*f*
Inadvertent bowel injury management, 701–702
bipolar bowel injury, 701–702
monopolar bowel injury, 701–702
repair bowel enterotomy, 701, 701*f*
thermal injury, 701–702
Incision techniques
abdominal transverse incisions
Cherney incision, 153–154, 154*f*
disadvantages, 151
Küstner incision, 153, 153*f*
Maylard incision, 154–156, 155*f*, 156*f*
Pfannenstiel incision, 151–152, 152*f*
space of Retzius, 153–154, 154*f*
abdominal vertical incisions
midline (median) incision, 156–158, 157*f*
paramedian incision, 158
delayed primary and secondary closure, 163–164
drains, use of, 163
for obese patients, 158–159
wound healing, physiology, 147–150, 148*f*
Incisional hernia (IH), 169–170, 170*t*

Incontinence. *See also* Anal incontinence; Stress urinary incontinence
abdominal hysterectomy, 435
Induced abortion
first trimester
epidemiology, 286
legal framework, 286
medication abortion, 291–292
preoperative counseling, 286–287
preoperative evaluation, 287
prophylactic medications, 287
surgical uterine vacuum aspiration, 287–291, 287*t*, 288*f*, 289*f*, 290*f*, 291*f*
second trimester pregnancy loss (*see* Second trimester induced abortions)
Infections
abortion, surgical complications, 298
cervical cancer, 524
dilatation and curettage, 257
episiotomy complications, 670
OASIS, 673
operative hysteroscopy complications, 282
surgical site, preoperative care, 49–51
vaginal hysterectomy complications, 396–397, 413
Infective endocarditis, 51
Inferior anal (rectal) nerve, 17
Inflammation, 148
Inflammatory bowel disease, 641
Infundibulopelvic ligaments, 536–537, 768–769, 769*f*
Initial laparoscopic entry, laparoscopy
accessory trocar placement, 180, 180*f*
Hasson open technique, 178–179, 179*f*
optical direct entry technique, 179
preoperative ultrasound slide-by test, 179–180

risks associated with entry, 180–181, 181*f*
Veress needle technique, 178, 178*f*, 179*f*
Inotropic and inodilator medications, 238
Inside-out transobturator sling, 614*f*
Instrument tie, operative laparoscopy, 176
Insulation failure, electrosurgery, 137
Insulin, 55
Integrated high-fidelity simulator, 192, 193*f*
Internal anal sphincter (IAS), 660*f*
Internal hernia, 210–211
Internal iliac and uterine arteries ligation, 125–126
Internal iliac artery ligation, 731–732, 731*f*, 732*b*
complications of, 733*t*
International Federation of Gynecology and Obstetrics (FIGO), 489
endometrial cancer, 489
corpus uteri, 489, 489*t*
pattern of spread, 489–490
Interrupted waveforms of electrical current, 132–134, 134*f*
Interstitial pregnancy
*vs.* angular, 357–358
asymptomatic, 357
cornual pregnancy and, 357–358
diagnosis, 357
fibrin glue, 360
morbidity and mortality, 357
persistence, 360
risk factors, 357
surgical treatment, 357–360, 361*f*
laparoscopic cornual resection, 360, 361*f*
laparoscopic cornuostomy, 359
laparotomy, 360
minimally invasive approach, 359
transcervical surgical approach, 360
ultrasound imaging, 357, 358*f*

Interval cytoreductive surgery, ovarian cancer, 543
Intestinal stomas, 724–726, 725*f*
Intra-abdominal infections, 227
Intramural myoma enucleation, 193–194, 194*f*
Intramyometrial coring technique, vaginal hysterectomy, 410, 411*f*
Intraoperative bleeding, hysteroscopic procedures, 281
Intraoperative complications
    bladder
        hysterectomy, 690–692, 693*b*, 693*f*
        postoperative diagnosis, 694
        prolapse repair, 692–693
        retropubic colposuspension, 692
        sling surgery, 693–694
        surgical anatomy, 681–682
    ureter
        acute ureteral injury, 685–686, 687*f*, 688*f*
        adnexal surgery, 683, 683*f*
        Boari flap construction, 686, 688, 692*f*
        common elements, 685, 685*t*
        hysterectomy, 682–683, 682*f*
        incidence, 679
        intraoperative diagnosis, 684–685, 684*t*
        location of injury and mechanism, 686*t*
        postoperative diagnosis, 685
        psoas hitch, 687–688, 691*f*
        radical pelvic surgery, 684
        retropubic surgery, 683
        surgical anatomy, 679–681, 680*f*, 681*f*
        ureteral–ileal interposition, 690, 692*f*
        ureteroneocystostomy, 686–687, 689*b*, 689*f*, 690*f*
        vaginal prolapse, 683–684
    urethra
        in gynecologic surgery, 694
        surgical anatomy, 682

Intraoperative cystoscopy, colpocleisis, 636
Intraoperative hemorrhage, 364–365
Intraperitoneal port (IP) placement of ovarian cancer, 542, 542*f*
Intrauterine adhesions
    dilatation and curettage, 257
    hysteroscopy, 274, 275*f*
Intrauterine contraceptive device (IUD), 249
Intrauterine lesions, hysteroscopic biopsy, 279
Intrauterine pregnancy loss. *See* Miscarriage
Intravascular embolization, 741
Intravenous iron therapy with/without erythropoiesis-stimulating agents, 419
Intravenous volume resuscitation
    electrolyte replacement, 240–241
    fluid choice, 240
    fluid status, 239–240
    oliguria, 240
Intrinsic renal dysfunctions, oliguria causes of, 240
Intrinsic sphincter deficiency, 603
Intubation, 70
Invasive carcinoma, 491
Invasive cervical cancer, 505, 508
Invasive squamous cell carcinoma, 475*f*, 479*f*
Irving method, 320, 322*f*–323*f*
Ischioanal fossa, 17
Ischiopubic rami, 11–12, 14, 19, 32*f*
Ischiorectal fossa, 564–567

## J

Jackson-Pratt drain, 163, 653–654
J-shaped incision, abdominal cavity, 155*f*

## K

Kegel exercises, 606

Keyes punch biopsy, 302, 303*f*
Kinetic energy, 130
Knots, 155
Kocher clamps, 114
KTP and argon lasers, 143
Küstner incision, 153, 153*f*

## L

Labia majora
    anterior commissure, 12
    finger-shaped process of fat, 14
    holocrine sebaceous glands, 14
    lymph nodes of, 17
    subcutaneous tissue of, 14, 25
Labia minora, 12, 14
    reduction techniques, 313*f*–314*f*
Labiaplasty, 314*b*
    edge resection technique, 313, 313*f*–314*f*
    labia minora size reduction, 312–313
    medical indications, 313
    postoperative management, 313–314
    relative contraindications, 313
    wedge resection, 313, 314*b*, 314*f*
Labor. *See* Delivery
Laminaria cervical dilators, 294–295, 295*f*
Laparoscopic myomectomy
    antiadhesion barriers, 385
    characteristics, 383
    closure, 385, 386*f*
    containment bag, 385, 386*f*
    GelPort device, 385
    incision, 389*f*, 392
    instrumentation, 378
    minilaparotomy, 382

patient positioning, 386–387
perioperative outcomes, 382
port placements, 383–384
randomized clinical trials, 383
recurrence, 392
suprapubic containment system, 385*f*–386*f*
suturing, 384
tissue extraction, 384
tourniquet, 384
uterine rupture in pregnancy, 383
vasopressin injection, 384
Laparoscopic sacrocolpopexy (LSC), 576, 576*f*
Laparoscopic subtotal (supracervical) hysterectomy (LSH), 440
advantages, 441
complications, 452–454
gynecologic surgery, 453
postoperative wound complications, 452–453
urologic injury, 453–454
vaginal cuff dehiscence, 452, 453*t*, 453*f*
equipment setup, 443
history, 440
mortality rate, 440
operative procedure
adnexal structures, 446–447, 448*f*
colpotomy, 448–451, 450*f*
electromechanical morcellation, 451
morcellation, 451–452
steps, 446*b*
tissue morcellation, 451
uterine corpus and vessels, 447–448
uterine extraction, 451
vaginal cuff closure, 452, 453*f*
patient positioning, 442
patient selection and preparation, 442

port placement, 443, 444*f*
uterine manipulation, 445, 445*f*
Laparoscopic/robotic procedures, anesthesia primer
anesthetic perioperative complications, 77–78, 77*t*
$CO_2$ insufflation, 76–77, 76*t*
enhanced recovery methods, 78
positioning, 76
steep Trendelenburg position, 77
vascular resistance, 76–77
ventilation optimization, 77
Laparoscopy, 766–767
abdominal entry, 178–179
alternative site entry, 177–178, 178*f*, 179*f*
capacitive coupling, 137
closure, 183–184
complications, 184–186
gastrointestinal injury, 185
nerve injuries, 185
trocar site hernia, 184
urinary tract injury, 185
vascular injuries, 184, 184*f*
contraindications, 173, 174*t*
diagnostic, 181–182, 182*t*
direct coupling in, 136–137
ectopic pregnancy, 353–354
cesarean scar pregnancy, 355–357, 356*f*
diagnostic laparoscopy, 353
salpingectomy, 353–354, 354*f*, 355*b*
salpingostomy, 353–355, 355*b*
equipment
ancillary instruments, 176, 176*f*
barbed sutures, 176
camera head, laparoscope, and light source, 175–176
endoloop, 176

endosurgical clips, 176
extracorporeal knots, 176
instrument tie, 176
insufflators, 175
tying intracorporeal knots, 176
fascial closure, 180, 180*f*
geriatric patients, 187–188
indications, 173, 174*t*
initial laparoscopic entry
accessory trocar placement, 180, 180*f*
Hasson open technique, 178–179, 179*f*
optical direct entry technique, 179
preoperative ultrasound slide-by test, 179–180
risks associated with entry, 180–181, 181*f*
Veress needle technique, 178, 178*f*, 179*f*
interstitial pregnancy
cornual resection, 359*b*, 360, 361*f*
cornuostomy, 359–360
obese patients, 186, 187*f*
operating room setup, 173–175, 174*f*, 175*f*
operative pelvic spaces, 182
ovarian cystectomy, 336*f*
ovarian diathermy, 346*f*
ovarian pregnancy, 362
ovarian transposition, 345*f*
patient positioning, 178
patient selection, 173
pediatric patients, 186
peritoneal entry
alternative entry sites, 177–178
palmer point entry, 177, 177*f*, 178*f*
umbilical entry, 177, 178*f*
pregnant patients, 186–187, 187*f*
salpingo-oophorectomy, 337*f*

secondary trocar placement, 178
surgical suite, 173–174, 174*f*
tissue extraction, 182–183, 183*f*
tubal sterilization, 321–326
bipolar coagulation, 322–323, 324*b*, 324*f*
complications, 326, 327*t*
general anesthesia, 321–322
incision, 322
patient positioning, 321–322
tubal occlusion, nonthermal methods of, 324–325, 325*f*, 326*f*
unipolar coagulation, 323–324
Veress needle, 321–322
Laparotomy. *See also* Minilaparotomy
catheter placement, 388–389, 388*f*
closure, 389–390, 390*f*
fibroid removal, 389–390, 390*f*
incision, 388–389, 388*f*–389*f*
myoma dissection, 388–389, 389*f*
myoma removal, 389–390, 390*f*
preoperative preparation, 385–386
pseudocapsule identification, 388–389, 389*f*
uterine cavity entered during dissection, 389–390, 390*f*–391*f*
vascular clamp application, 388–389, 388*f*
vasopressin injection, 384
Large intestine, anatomy, 697–699, 698*f*–699*f*
Large loop excision of the transformation zone(LLETZ). *See* Loop electrosurgical excision procedure (LEEP)
Large saphenous vein, 18
Large vessel repair, hemorrhage, 732–733
Laser energy, 142
Laser technology
applications, 142–143
$CO_2$ laser, 143

history of, 142
KTP and argon lasers, 143
neodymium doped yttrium aluminum garnet laser (Nd:YAG), 143
principles of, 142
safety measures, 144
types, 142–143, 143*t*
Lateral femoral cutaneous nerve, 101–102
Latzko technique, 650–651
Le Fort colpocleisis, 631–632, 633*b*
endometrial/cervical surveillance, 630
interrupted absorbable sutures, 631, 633*f*
procedure, 633, 633*b*
vaginal epithelium removing, 631, 632*f*
vaginal mucosa, rectangles of, 631, 632*f*
LEEP. *See* Loop electrosurgical excision procedure (LEEP)
Leiomyomas, 12
Lesser sac, 539
Levator ani
fibers of Luschka, 23
muscles, 21–22
and pelvic wall, 36–39
pubococcygeus and puborectalis portions, 19–20
stress continence mechanism, 32–33
Levator plate, 22, 28, 31
LIFT (ligation of intersphincteric fistula tract) procedure, 660, 661*f*
LigaSure technology, bipolar electrosurgical instruments, 139
Ligation of intersphincteric fistula tract (LIFT) procedure, 660, 661*f*
Light generators, hysteroscopy, 259–260, 261*f*, 262*f*
Liquid media, hysteroscopy
high viscosity, 266*t*, 267
low viscosity, 266*t*, 267
Liver function tests, preoperative care, gyne- cologic patient, 48
Liver resection/biopsy, ovarian cancer, 541–542
Local anesthesia, 63–64

dilatation and curettage, 251
Locking clamps, 114–115
Lone star retractor, 589
Long and curved Stone forceps, 115
Loop electrosurgical excision procedure (LEEP), 463–465, 463*f*, 464*f*
advantage, 463
equipment for, 463, 463*t*
excision depth, 464
hemostasis, 465
history, 463
insulated speculum insertion, 464
loop size and selection, 464
medications, 463
in outpatient setting, 463
“see-and-treat” strategy, 463
small lesion excision, 465, 465*f*
steps, 465, 465*b*
Loop ostomy closure, 719–721, 722*b*, 722*f*
Low malignant potential tumors, ovarian cancer, 545–546
Low rectovaginal fistula repair, RVFs, 660–661, 661*f*
Lower genitourinary tract
urethral diverticulum, 90–91
vulvar and vaginal cysts, 91, 91*f*
Lower limb
booted stirrups, 103–104, 103*f*
Candy cane stirrups, 104, 105*f*
clinical implications and management, 104
lumbosacral plexus anatomy, 100–103
nerve injury prevention, positioning, 103–104
self-retaining retractor blades, 104
Lower reproductive tract fistula, 639
anatomic classification, 640*t*
surgical management of, 646–666

fistula repair, principles of, 647–649
perioperative considerations, 647
Lower urinary tract fistula, 639–640
abdominal approach, 651–655, 652*f*–653*f*
conservative treatment, 645
diagnosis and evaluation, 642–645
retropubic-intravesical vesicovaginal fistula repair, 653–654, 654*f*
success rates, 656
surgical outcomes, 656–657
transperitoneal fistula repair, 652–653
urinary diversion for repair, 654–655
urinary incontinence, 657
vaginal approach, 649–651, 650*f*
vesicovaginal fistula repair, postoperative care after, 656–657
Lower vaginal atresia, 774–776, 775*f*–776*f*, 776*b*
Low-viscosity liquid media, hysteroscopy, 266*t*, 267
LSC (laparoscopic sacrocolpopexy), 576, 576*f*
Lumbosacral and brachial plexuses, 98
Lumbosacral plexus anatomy
and brachial plexuses, 98
lower limb
common peroneal nerve, 102–103
femoral nerve, 102
iliohypogastric and ilioinguinal nerves, 101
lateral femoral cutaneous nerve, 101–102
nerve roots and point of vulnerability, 100–103, 101*t*
obturator nerve, 102
pudendal nerve, 103
sciatic nerve, 102
Lungren, Samuel Smith, 317
Lungs. *See* Respiratory failure
Luschka, fibers of, 23
Lymph node assessment, cervical conization, 510–511

Lymphadenectomy, 522
endometrial cancer, 494–495
left paraaortic lymph node dissection, 494
mid–common iliac artery, 494
paraaortic lymph node dissection, 494–495
role and extent of, 494
surgical approach, 494–495
ovarian cancer, 537–538
Lymphatics
retroperitoneal spaces and lateral pelvic wall, 35–41
from superficial nodes, 18
of vulva, 26
Lynch syndrome, 501–502, 502*t*
Lysis of extensive adhesions and radical oncologic dissections, 194–195

## M

MAC (monitored anesthesia care), 64
Magnetic resonance imaging (MRI)
abdominal ectopic pregnancy, 364–365
endometrial cavity, 376
intracavitary myoma, 376, 377*f*
pelvic, 273
uterine artery embolization, 371
venous thromboembolisms, 217
Malecot catheter, 645
Malignant hyperthermia (MH), 66–67
Mannitol solution, low-viscosity solution, hysteroscopy, 267
Marshall-Marchetti-Krantz procedure, 607
Marsupialization, Bartholin glands, 306–307, 307*f*
Martius fibrofatty flap, 664, 664*b*
transposition, 664, 664*b*
Martius flap, 663–664
Massive transfusion protocol (MTP), 740–741, 740*t*

Mayer-Rokitansky-Küster-Hauser (MRKH) syndrome, 86
amenorrhea without pelvic pain, 776
midline atretic cord/band, 777, 777*f*
with uterine horn remnants, 777, 777*f*
Maylard incision, 154–156, 155*f*, 156*f*
Maylard-Bardenheuer incision, 155, 156*f*
MBP (mechanical bowel preparation), 709–710
McCall culdoplasty, 553–554, 554*f*–555*f*, 555*b*
*versus* uterosacral ligament suspension, 568
vaginal enterocele repairs, 599
vaginal hysterectomy, 407
McDonald technique, 640
McIndoe procedure, 779, 780*f*–781*f*
Mechanical bowel preparation (MBP), 709–710
Mechanical hemostatic agents, laparoscopy, 177
Mechanical hemostatic devices, 117
Medial thigh compartment, 18
Median nerve, 106
Medications, perioperative management, 54–56
Mediolateral episiotomy, 668–669, 669*f*
hematoma, 670
repair of, 670*f*
Melanoma, vulva, 483–484, 485*f*
Menopause, 435
Mesonephric (Wolffian) ducts, 86
Mesovarium, 25
Metabolic alkalosis, diagnostic workup, 234–237, 238*f*
Metabolic disorders, 435
Metabolic equivalents (METs), 45, 45*t*
Metal halide light generator, hysteroscopy, 260
Metal sutures, 121
Metastatic endometrial cancer, 500
Metronidazole, 764–765
MH (malignant hyperthermia), 66–67

Microsatellite instability (MSI), 501–502
Microvasculature, 743
Midlevel rectovaginal fistula repair, 657–659, 660*f*
Midline episiotomy, 640–641, 668–669, 669*f*
Midline (median) incision, 156–159, 157*f*, 158*f*
Midline plication/traditional posterior colporrhaphy, +/- perineorrhaphy, 595–598, 596*f*–597*f*
Midurethral sling complications
    bowel injury, 616
    cystotomy, 614–615
    de novo urinary urgency, 616
    incontinence after, 616–617
    persistent incontinence, evaluation and treatment of, 617
    surgical failure, risk factors for, 617
    surgical site infections, 616
    surgical site pain, 616
    urethral injury, 614
    urinary retention, 615
    urinary tract infections, 616
    vaginal mesh exposures, 615–616
    vaginal trocar perforation, 614
    vascular injury, 615
Minilaparotomy
    adnexal pathology, 333–334
    laparoscopic myomectomy, 382
    tubal sterilization, 318–321
        complications, 320–321
        interval tubal sterilization, 319–320, 321*f*
        morbidity, 318
        postpartum tubal sterilizations, 318–319
Minimally invasive approach to surgery, 189
Minimally invasive hysterectomy, 495–496, 497*b*
    history of, 439–440

laparoscopic supracervical (*see* Laparoscopic subtotal (supracervical) hysterectomy (LSH))
robotic-assisted total laparoscopic (*see* Robotic-assisted total laparoscopic hysterectomy (RA-TLH))
total laparoscopic (*see* Total laparoscopic hysterectomy (TLH))
Minimally invasive lymphadenectomy, 496, 497*b*
Minimally invasive surgery (MIS), 766
endometrial cancer
hysterectomy, 495–496
lymphadenectomy, 496
hemorrhage, 742
history, 439–440
in ovarian cancer, 542–543
Fagotti scoring algorithm, 542–543, 543*t*
laparoscopic scoring and assessment, 542–543, 543*t*
Mini-slings, 607
Miscarriage. *See also* Abortion
first trimester
definition, 284
diagnosis, 285
epidemiology, 284
management, 285–286
Misoprostol, 268
Mixed urinary incontinence, surgical treatment of, 625
Mixter clamp, 115
Modified Manchester procedure, 559–560, 560*f*
Monitored anesthesia care (MAC), 64
Monopolar bowel injury, 701–702
Monopolar cautery instruments, 191
Monopolar diathermy, 734–735, 736*f*
Monopolar electrical circuit
definition, 132, 133*f*
electrosurgery, 132, 133*f*
patient safety

active electrode monitoring, 137–138, 138*f*
capacitive coupling, 137, 137*f*, 138*f*
direct coupling, 136–137
insulation failure, 137
open activation, 136
Monopolar electrode, hysteroscopy, 261
Mons, 8, 12
Morcellation technique, 395, 410, 411*f*
Morcellators, 381
Moschowitz culdoplasty, 600
Motility disorders, 584–585
MRI. *See* Magnetic resonance imaging (MRI)
Müllerian duct anomalies (MDA), 86
Müllerian outflow tract anomalies
anatomic abnormalities, 786–787
endometriosis, 787
management, 784–786
nonobstructive anomalies, surgery for
class I anomalies, 779–781
class II anomalies, 781, 782*f*
class III anomalies, 782–784, 783*f*
class IV anomalies, 783*f*, 784
class V anomalies, 784, 785*b*, 785*f*
class VI anomalies, 784
nonobstructive type, 787
obstructive anomalies, surgery for
class I anomalies, 772–777
class II anomalies, 777
class III anomalies, 777–779, 778*f*, 779*f*
obstructive type, 787
traction sutures, 785
transverse vaginal septum, 784–785, 786*f*
undescended ovaries, 787
urologic anomalies, 786–787

Musculoaponeurotic layer, pelvic abdominal wall
bladder reflection, 7
flank muscles, 4–5
peritoneum, 7
rectus abdominis and pyramidal muscles, 3–4
rectus sheath, 5–7, 6*f*
transversalis fascia, 7
umbilicus, 7
Myocardial infarction, 205–206
Myoma extraction using ExCITE technique, 193, 193*f*
Myomectomy, 731
asymptomatic women, 371*t*
hysteroscopic approach, 374–382
preoperative optimization, 373
reduced intraoperative blood loss
mechanical tourniquets, 374
perioperative medical measures, 374*t*
ultrasonic device, 374
robot-assisted laparoscopic
advantage, 385–386
closure, 387, 388*f*
conventional laparoscopy, 385–386
enucleation, 386, 387*f*
hemostasis, 387
incision, 387, 387*f*–388*f*
instrumentation, 386
observational trials, 385–386
pseudocapsule identification, 387, 387*f*
tenaculum placement, 386–387
vasopressin administration, 387
surgical, indications, 373
symptoms, 370, 371*t*
*vs.* uterine artery embolization, 372
vaginal

cervix closure, 391
etiology, 391
hysteroscopy, 392
incision, 392
intraoperative instrument placement, 392*f*
Lahey clamp placement, 388–389, 392*f*
laparoscopic endoloops, 391
preoperative evaluation, 391
symptoms, 390–391
vaginal hemorrhage, 390–391
vasopressin administration, 391

## N

National Comprehensive Cancer Network guidelines, 491
National Healthcare Safety Network (NHSN), 220
National Surgical Quality Improvement Program (NSQIP), 45
Natural absorbable suture, 119–120
Natural permanent sutures, 120
Necrotic prolapsing fibroid, 391, 391*f*–392*f*
Needle drivers, 111–113, 113*f*
Negative pressure wound therapy (NPWT), 164–165, 164*f*
closed NPWT, 165
Neoadjuvant chemotherapy, ovarian cancer, 543
Neodymium-doped yttrium aluminum garnet laser (Nd:YAG), 143
Nerve injury, 616
laparoscopy complications, 185–186
Nerve-sparing radical hysterectomy, 522
Neuroendocrine tumors, 505
Neuromuscular blocking drug (NMBD), 70, 70*t*
Neuropathy, cervical cancer, 524
Neurovascular supply, pelvic abdominal wall
nerves of, 9–10, 10*f*
vessels of, 7–9, 8*f*, 9*f*
NMBD (neuromuscular blocking drug), 70, 70*t*

Noncatecholamine vasopressors, 238
Nonobstetric lower reproductive tract fistulas, 641–642
Nonobstructive anomalies, Müllerian outflow tract
    class I anomalies
        McIndoe procedure, 779, 780*f*–781*f*
        uterine transplant, 781
        Vecchietti procedure, 779–781
    class II anomalies, 781, 782*f*
    class III anomalies, 782–784, 783*f*
    class IV anomalies, 783*f*, 784
    class V anomalies, 784, 785*b*, 785*f*
    class VI anomalies, 784
Nonresectoscopic bipolar endometrial ablation, 141
Nonsteroidal anti-inflammatory drugs (NSAIDs), 55, 202, 251
Nonthermal methods, tubal occlusion, 324–325, 325*f*, 326*f*
    Filshie clip method, 324–325, 325*f*
    silicone band method, 325, 326*f*
    spring clips, 324
NSAIDs (nonsteroidal anti-inflammatory drugs), 55, 202, 251
NSQIP (National Surgical Quality Improvement Program), 45
Nutrition
    for frail patients, 47
    total parenteral nutrition (*see* Total parenteral nutrition (TPN))

## O

Obesity
    abdominoplasty, 159
    endometrial cancer, 500
    gynecologic disorders, 44
    laparoscopy, 186, 187*f*
    midline incision, 158–159, 158*f*
    panniculectomy, 159, 159*f*
    prevalence of, 158
Obesity-related conditions, 67, 68*t*

Obstetric anal sphincter injuries (OASIS), 670–674
antibiotics, 673
complications of
delayed repair of, 674
fecal incontinence, 673–674, 674*t*
infection and wound breakdown, 673
rectovaginal fistula, 674
end-to-end repair, 672, 672*f*, 673*b*
follow-up, 673
incidence, 670–671
overlapping repair, 672, 673*f*
perineal care, 673
postpartum management, 673
primary repair technique, 671*f*
risk factors, 670–671
Obstetric hemorrhage, surgery
aortic compression, 805–806, 806*f*
broad ligament and retroperitoneal hematoma, 810
extension of uterine incision, 810
management of, 804–805
adequate resuscitation, 805
communication, 805
early and comprehensive assessment, 804–805
incision and exposure, 805
patient positioning, 805
timely intervention, 805
measures to control, 805–807
pelvic packing, 806–807
peripartum hysterectomy
emergent peripartum hysterectomy, 812, 813*b*
for placenta accreta spectrum, 811–816, 812*t*, 813*b*, 814*f*, 815*f*
for uterine atony, 810–811, 811*b*
postoperative care, 816

surgical intervention for, 807–809
hypogastric artery ligation, 808–809, 809*f*
uterine atony, 807–808, 807*f*, 808*b*, 808*f*, 809*f*
surgical management of, 809–810
tourniquet uses, 806, 806*f*
uterine laceration, 810
uterine rupture, 809–810
Obstetric lower reproductive tract fistulas, 639–641
Obstructed defecation, 584–585
Obstructed hemivagina with ipsilateral renal anomaly (OHVIRA), 777–779, 778*f*
Obstructive anomalies, Müllerian outflow tract
class I anomalies
cervicovaginal atresia, 772–774, 773*f*–774*f*, 774*b*
lower vaginal atresia, 774–776, 775*f*–776*f*, 776*b*
uterovaginal atresia, 776–777, 777*f*
class II anomalies, 777
class III anomalies, 777–779, 778*f*, 779*f*
Obstructive shock, 232–233, 233*t*
Obstructive sleep apnea, gynecologic disorders, 44–45, 45*t*
Obturator nerve, 11, 12*f*, 102
injuries, 524
Obturator nerve injury, 186
Obturator neurovascular bundle, 612
Occult stress incontinence, 572
colpocleisis, 631
Occult stress urinary incontinence, 625–626
O'Connor-O'Sullivan retractor, 118
Ocular complications, 78
Ogilvie syndrome, 708, 708*f*
O'Leary stitch, 808, 808*b*
Oliguria, causes of, 240
Omental flap, 653*f*, 657
Omentectomy, ovarian cancer, 539, 540*f*

Oophorectomy, 768–769
endometrial hyperplasia, 492
Oophoropexy, 801
Open abdomen negative pressure system, 734*f*
Open activation, electrosurgery, 136
Open Hassan technique, laparoscopy, 177
Operative hysteroscopy, 140–141
electrosurgical devices and lasers, 271
endometrial ablation, 277*t*, 278, 278*f*
fallopian tube cannulation, 274–276, 276*f*
intrauterine adhesions, 274, 275*f*
intrauterine device removal, 279
intrauterine lesions, biopsy of, 279
myomectomy, 271–272, 271*b*
procedural steps, 271*b*
septate uterus, 273–274, 273*f*
sheath, 260–263, 263*f*, 264*f*, 265*f*
sterilization, 276
uterine polyps, 270*f*, 272–273
Opportunistic salpingectomy, 417
Optical direct entry technique, initial laparoscopic entry, laparoscopy, 179
Oral contraceptives, 55
Oral hypoglycemic agents, 55–56
Organ space infections, 227–228
Osmotic cervical dilators, 294, 295*f*
Ostomy, gastrointestinal tract, 726
Outside-in transobturator sling, 613*f*
Ovarian artery ligation, 731, 732*b*
Ovarian cancer, 93–94, 94*f*
advanced, surgery for
exploration, 535
pafolacianine, 535

pelvic tumor and radical oophorectomy, resection of, 536–537
primary debulking surgery, 535
appendectomy and cancer debulking, 538
diagnosed in pregnancy, 546
diaphragm tumor resection, 539–540
early, surgery for, 532–534
FIGO ovarian cancer staging, 532, 532*t*
surgical staging, early-stage ovarian cancer, 532, 533*t*
factors, 529–530, 530*t*
family history and genetic predisposition, 530
fertility-sparing surgery, 534–535, 534*t*
histological classification of, 529, 530*t*
hyperthermic intraperitoneal chemotherapy, 543–544
intraperitoneal port, placement of, 542, 542*f*
liver resection/biopsy, 541–542
low malignant potential tumors, 545–546
lymphadenectomy, 537–538
minimally invasive surgery in, 542–543
Fagotti scoring algorithm, 542–543, 543*t*
laparoscopic scoring and assessment, 542–543, 543*t*
neoadjuvant chemotherapy and interval cytoreductive surgery, 543
omentectomy, 539, 540*f*
palliative surgery
bowel obstruction management, 544–545
gastrostomy tube placement, 545
patterns of spread, 530–531, 531*f*
preoperative evaluation, 531–532
presentation, 530–531
rectosigmoid colon, resection, 538
recurrent disease, surgery for, 544
risk factors, 529–530
serum markers, 531–532, 532*t*

small bowel and ileocecal resection, 538
splenectomy, 540–541, 541*f*
surgery for
germ-cell tumors, 545
sex cord–stromal cell tumors, 545
surgical management, 529
urinary tract resection, 538–539
Ovarian cystectomy, 797–799, 798*f*, 799*b*
containment bag usage, 335, 336*f*
dermoid cysts, 335
endometrioma, 335
laparoscopic, 335, 336*f*
meticulous hemostasis, 334–335
procedural steps, 335*b*
Ovarian ectopic pregnancy
incidence, 360
laparoscopic image of, 362, 362*f*
surgical management, 362
symptoms, 360–361
ultrasound diagnostic criteria, 360–361
Ovarian endometrioma, 752, 753*f*
Ovarian function and symptom questionnaires, 435
Ovarian masses in prepubertal girls, 797*t*
Ovarian preservation, 800–801
Ovarian remnant resection, 757–758
Ovarian remnant syndrome, 757
Ovarian torsion, 87, 88*f*
Ovarian transposition, radical hysterectomy, 521–522
Ovarian tumors. *See* Ovarian cancer
Ovarian-Adnexal Reporting and Data System (O-RADS)
MRI, 96
US, 94, 95*f*
Ovary
lateral pole of, 24

lymphatic drainage of, 26
of vagina and uterus, 26
Overlapping repair, OASIS, 672, 673*f*
Oxytocin, 813

## P

Packed red blood cells, 739–740
Packing for control of hemorrhage, 733–734, 733*f*, 734*f*
Pafolacianine, ovarian cancer, 535
Paget disease, 483, 483*f*, 484*f*
Palmer point entry, peritoneal entry, laparoscopy, 177, 177*f*, 178*f*
Panniculectomy incisions, 159, 159*f*
Paraaortic lymphadenectomy, for obese patient, 500
Paramedian incision, 158
Paramesonephric (müllerian) ducts, 86
Pararectal space, 536–537, 731
cervical cancer, 515–516, 515*f*
laparoscopy, 182
Paravesical space, 536–537
cervical cancer, 515–516, 515*f*
dissection, 126–127
laparoscopy, 182
Parenteral therapy, 764–765
Parkland method, tubal sterilization, 320, 321*f*
Partial cystectomy, 538–539
Partial radical organ resection, 511
Passive drain, 163
Patient-side cart, daVinci Surgical System, 190, 190*f*
Pediatric patients, laparoscopy, 186
Pedicle transection, 422, 424*f*
Pelvic adhesive disease, 747–748
Pelvic brim and pararectal space dissection, 124–125, 125*f*
Pelvic connective tissue
urethral supports, 32–33, 32*f*

uterine ligaments, 30–31, 30*f*
vaginal attachments and extraperitoneal surgical spaces, 30*f*, 31–32, 32*f*
Pelvic exenteration, cervical cancer
positioning and preparation, 525
procedure, 521*b*, 524–525
surgical approach, 525–526
Pelvic floor
anal sphincters, 20–21, 20*f*
anatomy, 21*f*
anus, 28
blood supply and lymphatics, genital tract, 24*f*, 26
dysfunction (*see* Anal incontinence)
genital structures
adnexal structures and broad ligament, 24–25, 24*f*, 25*f*
uterus, 23–24
vagina, 22–23, 23*f*
ischioanal fossa, 13*f*, 20
levator ani and pelvic wall, 36–39
levator ani muscles, 21–22, 21*f*
lower urinary tract
bladder, 26–27
ureter, 26
urethra, 27–28
perineal body, 13*f*, 20
perineal membrane, 19–20, 19*f*
posterior triangle, 13*f*, 20
rectum, 28
sigmoid colon, 28
Pelvic hematoma, vaginal hysterectomy complications, 413
Pelvic imaging, abdominal hysterectomy, 418
Pelvic inflammatory disease (PID), 88
surgical management
algorithm, 762–763, 763*f*

antibiotic treatment, 764–765, 765*t*–766*t*
clinical manifestations, 762–764, 763*f*, 764*t*
delayed surgical management, 769
diagnosis, 764*t*
etiology, 762
intraoperative management, 767–769, 768*f*, 769*f*
microbial epidemiology, 762
percutaneous drainage, 765–766, 767*b*, 767*f*
postoperative considerations, 770
preoperative planning, 766–767, 768*f*
risk factors, 762
sequelae of infection, 764
wound management, 769–770
Pelvic lymph node assessment, 511
Pelvic malignancies, 641–642
Pelvic muscle rehabilitation, 606
Pelvic organ prolapse (POP), 551, 571. *See also site-specific prolapse*
anterior vaginal wall, 552
comparative outcomes
McCall culdoplasty *versus* uterosacral ligament suspension, 568
uterosacral ligament suspension *versus* sacrospinous ligament fixation, 567–568
vaginal hysteropexy comparative trials, 568–569
evaluation and diagnosis, 571
prevalence, 551
repair choice, 569
risk factor, 551–552
transvaginal apical suspension procedures, 553–567
anterior colporrhaphy and/or enterocele repair, 564
anterior vaginal mesh colpopexy/hysteropexy, 565*f*, 566–567
Breisky-Navratil retractors, 563–564, 563*f*

CSSL complex and ischial spine, 560–562, 562*f*
McCall culdoplasty, 553–554, 554*f*–555*f*, 555*b*
Modified Manchester procedure, 559–560, 560*f*
sacrospinous hysteropexy, 563*f*, 564*b*, 565–566, 566*b*
sacrospinous ligament fixation, 560–565, 561*f*–562*f*
uterosacral hysteropexy, 558–559, 559*f*
uterosacral ligament suspension, 555–558, 556*f*–557*f*, 557*b*
uterine preservation (hysteropexy) *versus* hysterectomy, 552–553
Pelvic Organ Prolapse Quantification (POPQ) examination, 587–588
Pelvic packing, 806–807
Pelvic pain
adnexal suspension, 759, 759*f*
etiology, 747
history, 747–748
ovarian remnant resection, 757–758
pelvic adhesive disease, 747–748
surgery, 748–749
uterine suspension, 758–759, 758*f*
Pelvic plexus, 38
Pelvic reconstruction. *See specific reconstruction procedures*
Pelvic retroperitoneal space
internal iliac vessels, 39–40, 39*f*, 40*t*
pelvic ureter, 10*f*, 40
Pelvic retroperitoneum exploration, 124–127
Pelvic surgery, complications of, 96
Pelvic tumor and radical oophorectomy, ovarian cancer, 536–537
Pelvic viscera, 22–28, 22*f*
genital structures, 22–26
lower urinary tract, 26–28
sigmoid colon and rectum, 28
Pelvis, female. *See specific anatomical structures in pelvic region*
Percutaneous arterial embolization, 741

Percutaneous drainage, 765–766, 767*b*, 767*f*
Perforation, uterine, operative hysteroscopy complication, 280, 281*f*
Perineal nerve, 17
Perineoplasty
    complication, 315
    indication, 314
    technique, 314–315, 315*f*
Perineorrhaphy, 594–598, 595*f*, 635–636, 635*f*
Perineotomy incisions, 159–160, 161*f*
Perineum
    anterior triangle layers of, 14*t*
    central point (tendon), 20
    erectile tissues of, 17
    membrane and perineal body, 20
    pelvic floor, 19–20, 19*f*
    perineal body, 13*f*, 20
    pudendal nerve, 13*f*, 15
    superficial compartment of, 13*f*, 14–15
Peripartum hysterectomy
    emergent peripartum hysterectomy, 812, 813*b*
    for placenta accreta spectrum, 811–816, 812*t*, 813*b*, 814*f*, 815*f*
    for uterine atony, 810–811, 811*b*
Peripheral nerve
    anatomy, 99, 99*f*
    compression and stretch injury, 99
Peripheral nerve blocks (PNBs), 74
Peripheral nerve injury
    incidence of, 98–99
    lower limb, 98
    neural anatomy and relationship, 99–100
    risk factors, 100
    Seddon's classification, 100
    upper limb, 98–99
Peripheral neuropathies during gynecologic surgery, 98

Perirectal fascia, 586
Peritoneal entry, laparoscopy
    alternative entry sites, 177–178
    palmer point entry, 177, 177*f*, 178*f*
    umbilical entry, 177, 178*f*
Peritoneum, 7
Persistent incontinence, 617
Persistent interstitial pregnancy, 360
Pfannenstiel incision, 151–152, 152*f*
Phenazopyridine, 643
Physiochemical (or Stewart) approach, 234
Physiological approach, 234
Placenta accreta spectrum (PAS), hysterectomy for, 811–816, 812*t*, 813*b*, 814*f*, 815*f*
Plain catgut, 120
Plasma kinetic technology, 139
Plasmin, 741
Platelet function, 742
Platelet transfusions, 214, 740–741
Plexus injury, 107
PNBs (peripheral nerve blocks), 74
Pneumatic compression devices, 431
Pneumonia, 207–208
POISE trial, 49
Politano-Leadbetter intravescial technique, 690*f*
Polydioxanone suture (PDS), 158–159
Polyester, 621
Polyglactin, 731–732
Polyglycolic acid sutures, 155–156, 156*f*
Pomeroy method, tubal sterilization, 320, 320*f*
Posterior colporrhaphy, 594–599, 596*f*
Posterior colpotomy, vaginal hysterectomy, 400–402, 402*f*
Posterior cul-de-sac dissection, 177–178
Posterior cul-de-sac peritoneum, 511

Posterior culdoplasty. *See* McCall culdoplasty
Posterior vaginal compartment support, colporrhaphy, 586
Posterior vaginal wall prolapse, colporrhaphy, procedures, 594
Postoperative bleeding. *See* Coagulation
Postoperative care
    abdominal hysterectomy, 431–432
    cardiac disease, 43–44
        cardiogenic shock, 205
        hypertensive disease, 205
        myocardial infarction, 205–206
        shock, 205
    colporrhaphy, 594–599
    ectopic pregnancy, 367
    enterocele repair, 599–600
    gastrointestinal tract complications
        antiemetic medications, 209, 209*t*
        postoperative ileus, 209–210
        postoperative nausea and vomiting, 209, 209*t*
        small bowel obstruction, 210–211, 210*t*
        total parenteral nutrition, 211–212
    gynecology (*see* Gynecology)
    vaginal hysterectomy, 413–414
Postoperative infection, abdominal hysterectomy, 434
Postoperative nausea and vomiting, 209, 209*t*
Postoperative neuropathy, abdominal hysterectomy, 434
Postoperative pain management
    catecholamines, 201
    fentanyl, 202
    hydromorphone, 202
    morphine, 202
    nonopioid-based medications, 202, 203*t*
    opiate-based medications, 202, 203*t*
    physiology, 201–202
    with preoperative assessment, 201

Postoperative transfusion, postoperative care
cryoprecipitate, 214
hemorrhagic shock, 214–215
platelet, 214
red blood cell, 214
Postpartum hemorrhage (PPH), 809
causes, 807
defined, 804
incidence, 804
uterine atony, 807
Postrenal dysfunctions, oliguria causes of, 240
Poststerilization regret
definition, 331
tubal sterilization and, 331
Povidone–iodine, preoperative care, gynecologic patient, 51
Power, concept of, 131
PPH. *See* Postpartum hemorrhage (PPH)
PPV (pulse pressure variation), 68
Precursor lesions, 469
Pregnancy. *See also* Delivery; Ectopic pregnancy
after sterilization, delayed, 330
cervical dysplasia in, 467
electrosurgery and, 144
laparoscopy, 186–187, 187*f*
preoperative care, 48
Preoperative care, gynecologic patient
adrenal insufficiency, perioperative, 55
adverse cardiac event, 49
antibodies, type and screen, 48
aspirin, 54
bacterial vaginosis, 51
bowel preparation, 52
cardiac testing, 47
chest X-ray, 47

coagulation testing, 47
complete blood count, 47
electrocardiogram, 47–48
*Chlamydia,* 51
chronic pain patients, 53–54
counseling, 43
for COVID 19, 49
creatinine, 48
diabetes, 44
electrocardiogram, 47–48
electrolytes and creatinine, 48
enhanced recovery system, 56, 57*t*–58*t*
glycemic control, 51
*Gonorrhea,* 51
hematocrit testing, 47
hemorrhage, 53
herbal and dietary supplements, 56
infection, 49–51
infections, 49–51
infective endocarditis, 51
liver function tests, 48
medications, 54–56
perioperative anticoagulation management, 54
perioperative strategies, risk factors, 49–54
POISE trial, 49
povidone-iodine, 51
pregnancy, 48
pregnancy test, 48
procedure-specific risk factors, 47
prophylactic antibiotics, 49–51
pulmonary function tests, 48
risk factors management, 49–54
surgical risk, 43–47
surgical site infection, 49–51

surgical site preparation and hair removal, 51
transfusion, 53
urogynecologic procedures, 51
venous thromboprophylaxis, 51–52
warfarin, 54
Preoperative counseling, 250
Preoperative ultrasound slide-by test, initial laparoscopic entry, laparoscopy, 179–180
Preoxygenation, 70
Prerenal dysfunctions, oliguria causes of, 240
Presacral neurectomy, endometriosis, 756, 756*f*, 757*b*
Presacral space
dissection, 126, 573
laparoscopy, 182
retroperitoneal spaces and lateral pelvic wall, 36–39, 37*f*
Prevesical space
laparoscopy, 182
of Retzius, 30*f*, 33–34
Primary cytoreductive surgery, 536*b*, 542–543
Primary debulking surgery, ovarian cancer, 535
Primary episiotomy repair, 669, 670*b*
Progestin therapy, endometrial hyperplasia, 491
Prolapse
abdominal hysterectomy, 435
repair, bladder, 692–693
Proliferation, wound healing, 149
Prophylactic antibiotics, 250
gynecologic patient, 49–51
Prophylactic forceps, 668
Prophylaxis with sequential compression devices, 493
Prothrombin time (PT), 730*t*, 740–741
Proton pump inhibitors, 55
Psoas hitch, 687–688, 691*f*
Pubic rami, 14, 20, 33–34

Pubocervical fascia, 586
Pubococcygeus and puborectalis portions of levator ani muscles, 19–20
Pubovaginal sling, 620–623
cystoscopy, 621
endopelvic fascia, perforation of, 621, 621*f*
intraoperative complications, 622–623
polyester, 621
postoperative complications, 623
prophylactic antimicrobial therapy, 621
Stress Incontinence Surgical Treatment Efficacy trial, 620
Pudendal (Alcock) canal, 15, 16*f*
Pudendal nerve, 103
perineum, 13*f*, 15
terminal branches of, 15–17, 16*f*
and vessels, 13*f*, 15
Pulmonary complications after gynecologic surgery, postoperative
anesthesia effects, 206, 206*t*
atelectasis, 206–207, 207*t*
endotracheal intubation and ventilatory support, 208
hospital-acquired pneumonia, 207–208, 208*t*
pneumonia, 207–208
pulmonary edema, 207
respiratory failure, 208–209
Pulmonary edema, 207
Pulmonary embolus, cervical cancer, 524
Pulmonary function tests, preoperative care gynecologic patient, 48
Pulse pressure variation (PPV), 68
Punch biopsy, 302, 303*f*
Push and spread technique, 123, 123*f*, 768, 768*f*
Pyramidal muscles, 153–154

## R

Radial nerve, 106–107

Radiation injury, bowel obstruction, management, 706–707, 707*f*
Radical abdominal trachelectomy, 511–512, 512*f*–513*f*
Radical hysterectomy, cervical cancer
abdominal exploration, 515
cardinal ligament dissection, 518–521, 519*f*, 520*f*
classes of, 513, 514*t*
hypogastric artery, uterine artery, bladder and ureter dissection, 516–518, 518*f*
indications, 513, 513*t*
lymph node assessment, cervical conization, 510–511
lymphadenectomy, 522
ovarian transposition, 521–522
paravesical and pararectal space development, 515–516
positioning, 514–515
vaginal closure, 521
Radical oophorectomy, 536–537
Radical pelvic surgery, ureter, 684
Radical trachelectomy, 512, 512*f*–513*f*
Radical vulvectomy, vulvar cancer, 476–477, 476*f*–477*f*, 479*b*
Radiofrequency, 130
Radiology primer
acute pelvic pain and abnormal uterine bleeding
adenomyosis, 89
endometrial polyps, 88–89
endometrioma, 89, 89*f*
hemoperitoneum, 86, 87*f*
hemorrhagic cyst, 86, 87*f*
ovarian torsion, 87, 88*f*
pelvic inflammatory disease, 88
tubal torsion, 87
tuboovarian abscess, 88, 88*f*
benign neoplastic disease processes
dermoid cysts, 89–90, 90*f*
fibroids, 89–90, 90*f*

complications of pelvic surgery, 96
computer tomography, 81–83, 82*t*
developmental disorders, 86, 86*f*–87*f*
gynecologic cancers
cervical cancer, 91–92, 92*f*
endometrial and uterine cancers, 92–93, 93*f*
ovarian cancer, 93–94, 94*f*
vaginal and vulvar cancer, 93
in gynecology, 84–86, 85*f*
lower genitourinary tract
urethral diverticulum, 90–91
vulvar and vaginal cysts, 91, 91*f*
magnetic resonance imaging, 83
O-RADS US and MRI classification system for adnexal masses, 94–96, 95*f*
positron emission tomography, 83–84
radiographs, 84
ultrasound (US) imaging, 81, 82*f*
RA-TLH. *See* Robotic-assisted total laparoscopic hysterectomy (RA-TLH)
Recombinant factor VIIa, 741–742
Rectal ampulla, 28
Rectal dysfunction, cervical cancer, 524
Rectal endometriosis, 752–753
Rectal J-pouch coloproctostomy, 716*f*
Rectosigmoid colectomy, 712, 714*b*, 714*f*
Rectosigmoid colon resection, ovarian cancer, 538
Rectovaginal fascia, 34, 586
Rectovaginal fistulas (RVFs), 639, 674
clinical presentation, 642
conservative treatment, 645–646
diagnosis and evaluation, 644–645
etiology and epidemiology, 639–642
nonobstetric lower reproductive tract fistulas, 641–642

obstetric lower reproductive tract fistulas, 639–641
surgical repair
abdominal repair, 657
fecal diversion, 662
fecal incontinence, 663
low rectovaginal fistula repair, 660–661, 661*f*
midlevel rectovaginal fistula repair, 657–659, 658*b*, 660*f*
postoperative care after, 662
procedure, transvaginal repair, 658*b*
surgical outcomes, 662–663
tissue interposition, 663–666
Rectovaginal space (RVS), 34, 519–520, 520*f*, 536–537, 560, 561*f*–562*f*, 572–573, 574*f*
laparoscopy, 182
Rectus abdominis muscle and pyramidal muscle, 3–4
Rectus sheath, 5–7, 6*f*
Red blood cell (RBC) transfusions, 214
Renal complications
electrolyte imbalances, 213
prerenal oliguria, 212, 213*t*
Renal function, 743
Renal tubule necrosis, 212
Resectoscope, 261, 263*f*
Resistance, 130–131
Respiratory failure, 208–209
Retrograde pyelogram, 644
Retroperitoneal hematoma, 810
Retroperitoneal spaces
lymphatics, 40–41
pelvic retroperitoneal space
internal iliac vessels, 39–40, 39*f*, 40*t*
pelvic ureter, 10*f*, 40
presacral space, 36–39, 37*f*
structures of, 35–36, 36*f*

Retropubic colposuspension, 692
Retropubic midurethral sling procedures
    stress urinary incontinence, 607–611
        cystoscopy, 610–611, 610*f*
        postoperative voiding trial, 611
        procedure, 611*b*
        retropubic space, 609, 609*f*
        Retzius space, retropubic trocars, 608*f*
        rigid catheter, 609*f*
        vaginal incision for, 608*f*
        vaginal tension-free tape insertion, 610*f*
Retropubic space, 608*f*, 609*f*
    laparoscopy, 182
Retropubic space dissection, 124*f*, 126
Retropubic surgery, ureter, 683
Retropubic-intravesical vesicovaginal fistula repair, 653–654, 654*f*
Return electrode
    dispersive electrode, 131–132, 132*f*
    monitoring, 132
Rigid urethral catheter, 609
Ringer lactate, hysteroscopy, 266*t*, 267
Ring/sponge forceps, 115
Risks associated with entry, initial laparoscopic entry, laparoscopy, 180–181, 181*f*
Robot-assisted laparoscopic myomectomy
    advantage, 385–386
    closure, 387, 388*f*
    conventional laparoscopy, 385–386
    enucleation, 386, 387*f*
    hemostasis, 387
    incision, 387, 387*f*–388*f*
    instrumentation, 386
    observational trials, 385–386
    pseudocapsule identification, 387, 387*f*

tenaculum placement, 386–387
vasopressin administration, 387
Robot-assisted microsurgical tubal reanastomosis, 342–343, 343*f*–344*f*, 345*b*
Robotic sacrocolpopexy (RSC), 576–579, 578*f*–580*f*
Robotic surgery
daVinci Surgical System (*see* daVinci Surgical System)
docking Si and Xi platforms, 191–192
fascial closure, 193
in gynecology
fine dissection procedures, 194–195, 195*f*
large patients and pathology, 195
suture-dependent procedures, 193–194, 194*f*
integrated high-fidelity simulator, 192, 193*f*
limitations, 189
port placement, 191–192
tissue extraction, 193
Robotic-assisted laparoscopy, endometrial cancer staging, 495
Robotic-assisted sacrocolpopexy (RASC), 194, 194*f*
Robotic-assisted total laparoscopic hysterectomy (RA-TLH)
advantages, 441–442
complications, 452–454
gynecologic surgery, 453
postoperative wound complications, 452–453
urologic injury, 453–454
vaginal cuff dehiscence, 452, 453*t*, 453*f*
equipment setup, 443
history, 440
operative procedure
adnexal structures, 446–447, 448*f*
colpotomy, 448–451, 450*f*
electromechanical morcellation, 451
morcellation, 451–452
steps, 446*b*

tissue morcellation, 451
uterine corpus and vessels, 447–448
uterine extraction, 451
vaginal cuff closure, 452, 453*f*
patient positioning, 442
patient selection and preparation, 442
port placement, 444, 444*f*
uterine manipulation, 445, 445*f*
Robotics in endometriosis surgery, 195
RSC (robotic sacrocolpopexy), 576–579, 578*f*–580*f*
Rubbing/wiping dissection, 124, 124*f*
Rudimentary horn pregnancy, 365–366
RVFs. *See* Rectovaginal fistulas (RVFs)
RVS. *See* Rectovaginal space (RVS)

## S

Sacral promontory dissection, 573, 575*f*
Sacrocolpoperineopexy, 580, 599
Sacrocolpopexy, 572–574
complications, 581–582
indications, 571
minimally invasive approaches, 574–579
by open technique/laparotomy, 572–574
outcomes, 580–581
postoperative considerations, 580–582
preoperative considerations, 572
procedure, 573*b*
sacrocolpoperineopexy, 580
sacrohysteropexy, 579–580
surgical technique, 572
mesh attachment, 573–574, 575*f*
preoperative bowel preparation, 572
sacral promontory dissection, 573, 575*f*
vaginal vault dissection, 571, 574*f*

urinary incontinence, 572
Sacrohysteropexy, 571, 579–580
Sacrospinous hysteropexy, 563*f*, 564*b*, 565–566, 566*b*
Sacrospinous ligament
fixation, 560–565, 561*f*–562*f*
*vs.* uterosacral ligament suspension, 567–568
region, 34–35, 34*f*
Saline solution, hysteroscopy, 267
Saline-infused sonohysterography (SIS), 81
Salpingectomy
bilateral, tubal sterilization, 328–329
at cesarean section, 328
complications, 328–329
ectopic pregnancy
laparoscopic technique, 353
tubal, 353–355, 355*b*, 366
interval, 328
postpartum, 328
Salpingo-oophorectomy, 423
adnexal structures, 447, 449*f*
vaginal hysterectomy, 412, 412*f*
Salpingostomy, 341*f*–342*f*
ectopic pregnancy, 353
procedure, 353
*vs.* salpingectomy, 354
Sarcomas, 484–485
Satinsky clamps, 737
Scalpels, 110–111, 111*f*
Scarpa fascia, 14
Schuchardt incision, 160, 161*f*
Sciatic nerve injury, 102, 186
Scissors, 111, 112*f*
Second trimester induced abortions
dilation and evacuation procedure, 294–296

cervical preparation, 294–295, 295*f*
evacuation, 296, 296*f*
inspection of products, 296
mechanical cervical dilatation, 296
mechanical cervical dilation, 294
rapid manual dilation, 294
returning to operating room, 295
tenaculum placement, 295
ultrasound guidance, 295–296
epidemiology, 292
management, 292–296
counseling, 292–293
dilation and evacuation, 293*b*, 294–296
hysterotomy, 292–293
labor induction methods, 292
preprocedure medications and preparation
antibiotics, 293
pain and anxiety management, 293
preprocedural fasting, 293
preventing blood loss, 293–294
vasopressin administration, 293–294
venous thromboembolism prophylaxis, 293
Secondary cytoreductive surgery, 544
Secondary trocar placement, operative laparoscopy, 178
Seddon's classification of nerve injury
axonotmesis, 100
neurapraxia, 100
neurotmesis, 100
Selective progesterone receptor modulators, 419
Self-induced abortion, 286
Self-retaining retractor
abdominal hysterectomy, 420
blades, 104
Sentinel lymph node (SLN), 508–509

mapping, endometrial cancer, 496–500
accurate detection of, 497
distribution, 498, 498*f*
dye injection method, 497–498
injection, 497–498, 497*f*
lymphatic assessment algorithm, 499, 499*f*
pathology, 499–500
steps, 497*b*
surgical approach, 498–499
radical hysterectomy, 514–515
in vaginal cancer, 472–473
Septate hymenal variants, 793, 793*f*
Septate uterus, hysteroscopic surgery, 273–274, 273*f*
Septic shock, 770
Serum electrolytes, 203
Setons, 645–646
Sex cord–stromal cell tumors, 545
Sexual function, 435
Shave biopsy, 302–303
Shock, 205. *See also* Hypovolemic shock; Septic shock
critical care
acid-base disturbances, 234–237
cardiogenic shock, 232, 233*t*
definition, 232
distributive shock, 232, 233*t*
hemodynamic monitoring, 234, 235*t*–237*t*
hypovolemic shock, 232, 233*t*
management of, 233, 233*b*
obstructive shock, 232–233, 233*t*
oxidative stress and cellular injury, 232
vasopressors or inotropes, 237–238, 239*t*
Sigmoid colon, 525
Silicone band method, tubal occlusion, 325, 326*f*
Simple hyperplasia (SH), 491

Simple hysterectomy with lymph node assessment, 511
Simplified Acute Physiology Score (SAPS-II), 234
Sims retractor, 269, 270*b*, 608
Sims speculum/split speculum, 643
Site-specific repair, colporrhaphy, 598
Skene duct cysts, 91
Skin, and subcutaneous tissue, pelvic abdominal wall, 3
Sliding knots, 122
Sling surgery, bladder, 693–694
SLN. *See* Sentinel lymph node (SLN)
small bowel anastomosis, gastrointestinal tract, 723–724
Small bowel and ileocecal resection, ovarian cancer, 535
Small bowel obstruction, 210–211, 210*t*
Small intestine, 697, 698*f*
Smead-Jones layered closure technique, 163, 163*f*
Smokers, gynecologic disorders, 45
"Snip-push-spread" technique, 423–424
Sorbitol, low-viscosity solution, hysteroscopy, 266*t*, 267, 280–281
Space of Retzius, 124*f*, 126, 182
Sparking (arcing), 137
Sphincter urethrovaginalis muscle, 19–20
Spinal anesthesia, 73
Splenectomy, ovarian cancer, 540–541, 541*f*
Spontaneous abortion. *See* Abortion
Spring clip method, tubal occlusion, 324
Squamous carcinoma, 505
Standard hysteroscopic tools, 261, 264*f*
Standard physiological approach, 234
Stapled transanal rectal resection (STARR), 600
Stapling devices, 117, 117*f*
STARR procedure, 600
Statins, 56
Sterilization
    efficacy, 329

hysteroscopy, 276
minilaparotomy, 318–319
pregnancy rates, 317, 318*t*
safety, 329–330
Stomach, 696–697, 697*f*
STOP-Bang Questionnaire: Screening Tool for Obstructive Sleep Apnea, 44, 45*t*
Strassman unification, 783*f*, 784
Stress urinary incontinence (SUI), 603, 625
initial evaluation, 604–606
additional evaluation of, 605–606
history, 604
physical examination, 604–605
midurethral slings, complications from
bowel injury, 616
cystotomy, 614–615
de novo urinary urgency, 616
incontinence after, 616–617
persistent incontinence, evaluation and treatment of, 617
surgical failure, risk factors for, 617
surgical site infections, 616
surgical site pain, 616
urethral injury, 614
urinary retention, 615
urinary tract infections, 616
vaginal mesh exposures, 615–616
vaginal trocar perforation, 614
vascular injury, 615
nonsurgical treatment of, 606–607
occult SUI, 625–626
pathophysiology, 603
surgical treatment of, 607–625
Burch retropubic urethropexy, 617–620
pubovaginal sling, 620–623

retropubic midurethral sling procedures, 607–611
transobturator midurethral sling, 612–613
urethral bulking agents, 623–625
urethral injury, 614
Stretch injury during laparoscopy and steep Trendelenburg, 107
Subcutaneous emphysema, 78
Suction devices, 116
SUI. *See* Stress urinary incontinence (SUI)
Superficial transverse perineal muscles, 14*t*, 15, 20
Supracervical hysterectomy, 427, 429*f*, 430*b*
Supracervical (subtotal) *vs.* complete (total) hysterectomy, 430
Surgeon console, daVinci Surgical System, 189, 190*f*
Surgery
for Bartholin glands
abscesses, 304–308
carcinomas, 304
cysts, 304–308
excision, 307–308, 307*t*, 308*f*, 309*t*
incision and drainage using Word catheter, 305–306, 305*b*
location, 304, 305*f*
marsupialization, 306–307, 307*f*
supplies for placement, 305, 305*b*
vaginal cancer, 472–473
vaginal preinvasive disease, 469–472
$CO_2$ laser vaporization, 471
vaginal biopsy, 470–471
vaginectomy, 471–472, 472*b*
for vestibule disorders
chronic vulvar pain process, 310
cotton swab testing, 310
excision, 310–311
vestibulectomy, 310–311, 311*b*
vulva preinvasive disease
excision, 473

high-grade VIN, 473
vulvar malignancies
Bartholin gland carcinoma, 484
basal cell carcinoma, 484
malignant melanoma, 483–484, 485*f*
Paget disease, 483, 483*f*, 484*f*
sarcomas, 484–485
verrucous carcinoma, 485
vulvar preinvasive disease
$CO_2$ laser vaporization, 474
simple vulvectomy, 474, 474*b*, 475*f*
vulvar biopsy, 473
Surgical complications, in abortion
adverse reproductive outcomes, 298
cancer, 299
cervical injury, 297
hematometra, 297
hemorrhage, 296–297
impact on mental health, 298
infection, 298
mortality, 299
retained tissue, 298
Rh sensitization, 298
uterine perforation, 297–298
Surgical knots, 122, 122*f*
Surgical needles, 121–122, 121*f*
Surgical Quality Improvement Program (SQIP) guidelines, 710
Surgical robots, 189
Surgical site infection (SSI)
antibiotic hypersensitivity, 230
in children and adolescents
antibiotic dosing, 789–790, 790*t*
prophylactic antibiotics, 789–790
classification, 220, 221*t*

"clean" or "clean-contaminated" surgery, 220
cost, 220
evaluation
bacterial cultures, 226
fever, 224–225, 225*t*
imaging, 226
laboratory testing, 225–226
physical examination, 225
high-risk patients, 220
midurethral slings, complications from, 616
patient-level risk factors, 221*t*
bacterial vaginosis, 222
immune deficiency, 222
methicillin-resistant Staphylococcus aureus, 222
smoking, 222
weight/obesity, 221
postoperative infection
*Clostridium difficile* infection, 226–227
pneumonia, 226
urinary tract infection, 226
postoperative outcome evaluation, 220
procedure-level risk factors
abdominal closure protocol, 224
duration of surgery, 224
normothermia, 223–224
perioperative antibiotics, 221, 223
perioperative "bundle," 224
skin preparation at home, 222–223
skin preparation in operating room, 223
treatment
deep incisional SSIs, 221*t*, 227, 227*b*
necrotizing infections, 228–229, 229*b*
organ space infections/intra-abdominal infections, 221*t*, 227–228

superficial/incisional infection, 221*t*, 227
vaginal cuff infection, 229
vulvar infections, 229–230
Surgical smoke, electrosurgery, 145
Suture-dependent procedures, robotic surgery in gynecology, 193–194, 194*f*
Sutures
metal sutures, 121
natural absorbable, 119–120
natural and synthetic materials, 120–121
natural permanent, 120
surgical knots, 122, 122*f*
surgical needles, 121–122, 121*f*
synthetic permanent sutures, 121
synthetic sutures, 120–121
Sweat glands, eccrine, 14
Synthetic absorbable braided sutures, 120
Synthetic absorbable monofilament sutures, 120–121
Synthetic barbed sutures, 121
Synthetic permanent sutures, 121
barbed sutures, 121
Synthetic sutures
absorbable braided, 120
absorbable monofilament, 120–121

## T

Tampon test, 643
Telescopes, hysteroscopy, 259–260, 261*f*, 262*f*
Tenaculums, 115
Tertiary cytoreductive surgery, 544
Thermal ablation, cervical dysplasia, 460, 460*f*–461*f*
Thermal injury, 734–735
complications
electrosurgery, 271

laser surgery, 271
Three-arm robotic trocar placement, 191*f*–192*f*
Thrombin, postpartum hemorrhage, 804
THX-26 needle, 620
Thyroid disease, menstrual bleeding, 371
Thyroid retractors, 118
Tissue clamps, 113–115, 114*f*
Tissue effects
dispersive electrode placement, 136
electrode shape, 135, 136*f*
tissue impedance, 135–136
of waveform and tissue contact, 134–135, 134*t*
Tissue extraction, 193
laparoscopy, 182–183, 183*f*
Tissue (thumb) forceps, 113–115, 114*f*
Tissue impedance, 135–136
Tissue sealants and hemostatic agents, 736*t*
TLH. *See* Total laparoscopic hysterectomy (TLH)
Tobacco use, gynecologic disorders, 45
Total laparoscopic hysterectomy (TLH), 439–440
advantages, 440–441
challenges, 452
complications, 452–454
gynecologic surgery, 453
postoperative wound complications, 452–453
urologic injury, 453–454
vaginal cuff dehiscence, 452, 453*t*, 453*f*
equipment setup, 443
history, 439–440
operative procedure
adnexal structures, 446–447, 448*f*
colpotomy, 448–451, 450*f*
electromechanical morcellation, 451
morcellation, 451–452

steps, 446*b*
tissue morcellation, 451
uterine corpus and vessels, 447–448
uterine extraction, 451
vaginal cuff closure, 452, 453*f*
patient positioning, 442
patient selection and preparation, 442
port placement, 443, 444*f*
uterine manipulation, 445, 445*f*
Total parenteral nutrition (TPN), 211–212
Total vaginal hysterectomy (TVH), 439
Tourniquet uses, obstetric hemorrhage, 806, 806*f*
Traction/countertraction technique, 123, 124*f*
Traditional midline posterior colporrhaphy, 599*b*
Tranexamic acid (TXA), 741
Transanal approach, colporrhaphy, 598
Transfusion, 53
abdominal hysterectomy, 433
Transobturator midurethral sling
stress urinary incontinence, 612–613
inside-out transobturator sling, 614*f*
midurethral placement, 612
outside-in transobturator sling, 613*f*
Transrectal–endorectal advancement flap procedure, 657–659, 659*f*–660*f*
Transrectal/transvaginal repair, 657–659, 658*b*, 659*f*–660*f*
Transureteroureterostomy, 688*f*
Transurethral/suprapubic catheter drainage, 655–656
Transvaginal apical suspension procedures, pelvic organ prolapse, 553–567
anterior colporrhaphy and/or enterocele repair, 564
anterior vaginal mesh colpopexy/hysteropexy, 565*f*, 566–567
Breisky-Navratil retractors, 563–564, 563*f*
CSSL complex and ischial spine, 560–562, 562*f*

McCall culdoplasty, 553–554, 554*f*–555*f*, 555*b*
Modified Manchester procedure, 559–560, 560*f*
sacrospinous hysteropexy, 563*f*, 564*b*, 565–566, 566*b*
sacrospinous ligament fixation, 560–565, 561*f*–562*f*
uterosacral hysteropexy, 558–559, 559*f*
uterosacral ligament suspension, 555–558, 556*f*–557*f*, 557*b*
Transversalis fascia, 7
anterior abdominal wall, 7, 8*f*
prevesical space, 33–34
Transverse incisions
Cherney incision, 153–154, 154*f*
disadvantages, 151
Küstner incision, 153, 153*f*
Maylard incision, 154–156, 155*f*, 156*f*
Pfannenstiel incision, 151–152, 152*f*
space of Retzius, 153–154, 154*f*
Transverse loop colostomy, 538, 545
Transverse vaginal septum, 784–785, 786*f*
Trauma-induced coagulopathy (TIC), 743
Trocar site hernia, laparoscopy complications, 184
Tubal ectopic pregnancy, 353–355, 355*b*
Tubal occlusion, hysteroscopic procedure, 326–327
Tubal reanastomosis, 194, 194*f*
Tubal sterilization
bilateral salpingectomy, 327–329, 327*b*
at cesarean section, 328
complications, 328–329
interval, 328
postpartum, 328
efficacy, 329
historical perspectives, 317
interval, 319–320
modified Pomeroy procedure, 319–320
Parkland method, 320, 321*f*

laparoscopy, 321–326
bipolar coagulation, 322–323, 324*b*, 324*f*
complications, 326, 327*t*
general anesthesia, 321–322
incision, 322
patient positioning, 321–322
tubal occlusion, nonthermal methods of, 324–325, 325*f*, 326*f*
unipolar coagulation, 323–324
Veress needle, 321–322
long-term or delayed complications, 330
CREST study, 330
delayed pregnancy, 330
ectopic risk, 330
menstrual changes after, 331
minilaparotomy, 318–321
complications, 320–321
morbidity, 318
postpartum, 318–319
preoperative evaluation, 317–318
regret, 331
safety, 329–330
Tubal torsion, 87
Tuboovarian abscess (TOA), 88, 88*f*
Tumor. *See* specific types of tumors
Tungsten light generator, hysteroscopy, 260

## U

Uchida method, 323*f*
Ulnar nerve, 106
Ultrasonic energy instruments, 191
Ultrasonic technology, 141–142
Ultrasonography, ectopic pregnancy diagnosis, 350
Ultrasound

abdominal ectopic pregnancy, 364–365
cervical pregnancy, 363, 363*f*
cesarean scar pregnancy, 355–357, 356*b*, 356*f*
heterotopic pregnancy, 366, 366*f*
interstitial pregnancy, 357, 358*f*
ovarian pregnancy, 360–361
rudimentary horn pregnancy, 365
uterine leiomyoma, 376
Umbilical entry, peritoneal entry, laparoscopy, 177, 178*f*
Umbilicus, 7
Undescended ovaries, 787
Unicornuate uterus, 86, 86*f*–87*f*
Universal cystoscopy, abdominal hysterectomy, 432–433
"UPLIFT" procedure, 758–759
Upper limb, 98–99
brachial plexus anatomy, 104–107
clinical implications and management, 108
positioning, nerve image prevention, 107–108
arm boards, 107, 107*f*
head positioning, 108
patient's arms, tucked, 107, 108*f*
Ureter
dissection, 516–518, 518*f*
in gynecologic surgery
adnexal surgery, 683, 683*f*
hysterectomy, 682–683, 682*f*
radical pelvic surgery, 684
retropubic surgery, 683
vaginal prolapse, 683–684
incidence, 679
intraoperative diagnosis, 684–685, 684*t*
postoperative diagnosis, 685
surgical anatomy, 679–681, 680*f*, 681*f*
techniques

acute ureteral injury, 685–686, 687*f*, 688*f*
Boari flap construction, 686, 688, 692*f*
common elements, 685, 685*t*
location of injury and mechanism, 686*t*
psoas hitch, 687–688, 691*f*
ureteral–ileal interposition, 690, 692*f*
ureteroneocystostomy, 686–687, 689*b*, 689*f*, 690*f*
Ureteral management, cervical cancer, 522–524
Ureteral resection, 538–539
Ureteral stents, abdominal hysterectomy, 432
Ureteral–ileal interposition, 690, 692*f*
Ureteroneocystostomy, 686–687, 689*b*, 689*f*, 690*f*
Ureteroureterostomy, 686, 687*f*
Urethra
anatomy, 19*f*, 27–28
in gynecologic surgery, 694
lymphatics, 17–18
surgical anatomy, 682
Urethral bulking agents, 623–625
bladder neck, periurethral injection at, 624–625, 624*f*
complications, 625
products, 623
transurethral approach via cystoscopy, 624–625
Urethral carina of vagina, 23
Urethral diverticulum, lower genitourinary tract, 90–91
Urethral injury, 614
Urethral lymphatics, 17–18
Urethropelvic ligaments, 682
Urethrovaginal fistulas, 655*f*, 664
Urinary diversion, lower urinary tract fistula, 654–655, 655*f*
Urinary incontinence, lower urinary tract fistula, 657
Urinary retention, 615
Urinary tract infections (UTIs)
midurethral slings, complications from, 616

pubovaginal sling, 607, 620–623
Urinary tract injury, 434
laparoscopy complications, 185
vaginal hysterectomy complications, 413
Urinary tract resection, ovarian cancer, 538–539
Urodynamics, 588
Urogenital diaphragm, 19
Urogynecologic procedures, 51
Urologic complications, cervical cancer
bladder management, 522
ureteral management, 522–524
U.S. Pharmacopeia (USP), 119
Uterine adnexa
fallopian tubes, 24*f*, 25
ovaries, 24*f*
Uterine artery
dissection, 516–518, 518*f*
ligation, 807, 809*f*
skeletonization, 424–426
Uterine artery embolization (UAE), 89–90
Uterine artery embolization (UAE), 371
Uterine artery ligation (UAL), 731, 732*b*
Uterine atony, 807–808, 807*f*, 808*b*, 808*f*, 809*f*
hysterectomy for, 810–811, 811*b*
Uterine bleeding. *See* Hemorrhage
Uterine cancer, 92–93, 93*f*
surgery for (*see* Endometrial cancer)
Uterine compression sutures, 807
Uterine C-section scar defect, hysteroscopic surgery and, 279–280, 279*f*
Uterine dilators, 249
Uterine incision, extension of, 810
Uterine laceration, hemorrhage, surgical management of, 810
Uterine leiomyoma

characteristics associated with prevalence, 371*t*
classification, 370
FIGO classification system, 371*f*
incidence, 371*t*
management, 370
nonsurgical treatment
expectant management, 372
medical treatment, 372
progesterone receptor modulators, 372
thermoablative technique, 372
preoperative investigation, 370–372
surgical myomectomy (*see* Myomectomy)
symptoms, 370
Uterine manipulators, laparoscopy, 173–175, 174*f*, 175*f*
Uterine perforation
abortion, surgical complications, 297–298
dilatation and curettage, 256, 256*b*
operative hysteroscopy procedure, 280, 281*f*
Uterine polyps, hysteroscopy, 270*f*, 272–273
Uterine preservation (hysteropexy) *versus* hysterectomy, 552–553
Uterine rupture hemorrhage, surgical management of, 809–810
Uterine sarcoma, 489–490, 501
Uterine septum (partial/complete), 785*b*
Uterine suspension, 758–759, 758*f*
Uterine synechiae
risk factor, 274
treatment, 274
Uterine transplant, 781
Utero-ovarian pedicle isolation, 423, 424*f*
Uterosacral hysteropexy, 558–559, 559*f*
Uterosacral ligament, 26, 29–30, 516, 517*f*, 519–520, 520*f*
suspension, 555–558, 556*f*–557*f*, 557*b*, 567–568
Uterovaginal atresia, 776–777, 777*f*
Uterovaginal prolapse, transvaginal apical suspension procedures

anterior colporrhaphy and/or enterocele repair, 564
anterior vaginal mesh colpopexy/hysteropexy, 565*f*, 566–567
Breisky-Navratil retractors, 563–564, 563*f*
CSSL complex and ischial spine, 560–562, 562*f*
McCall culdoplasty, 553–554, 554*f*–555*f*, 555*b*
Modified Manchester procedure, 559–560, 560*f*
sacrospinous hysteropexy, 563*f*, 564*b*, 565–566, 566*b*
sacrospinous ligament fixation, 560–565, 561*f*–562*f*
uterosacral hysteropexy, 558–559, 559*f*
uterosacral ligament suspension, 555–558, 556*f*–557*f*, 557*b*
Uterus. *See also specific uterine anomalies*
amputation of, 447–448, 449*f*, 450, 451*f*
normal MRI anatomy, 85, 85*f*
septate, 273–274, 273*f*

## V

Vagina
cancer, 472–473
carcinoma, FIGO Staging for, 469, 470*t*
connective tissue attachments, 30*f*, 31–32, 32*f*
structure, 22–23, 23*f*
Vaginal approach, graft augmented, 599
Vaginal axis, 23*f*
Vaginal cancer, 93
Vaginal closure, cervical cancer, 521
Vaginal cuff dehiscence, 434
Vaginal delivery, 551–552
Vaginal enterocele repairs, 599
Vaginal hysterectomy, 491
adnexectomy at, 412
advantages, 395, 395*t*
bivalve technique, 410, 411*f*
cervical elongation, 408–410, 409*f*
challenges, 407

complications, 413
contraindications, 395
difficult anterior colpotomy, 407–408
    blunt instrument, 408
    cervix and uterus during dissection, 408, 408*f*
    dissection beneath cesarean section, 407–408, 408*f*
    hysterectomy specimen, 408, 408*f*
    retrograde filling bladder, 408
    sharp dissection, 408
enlarged uterus for, 410–411
historical perspective, 394–395
indications, 394
intramyometrial coring technique, 410, 411*f*
intraoperative considerations
    anterior colpotomy, 398–400, 401*f*
    basic principles, 397–398
    cul-de-sac peritoneum, 402, 402*f*
    cystoscopy, 407
    dorsal lithotomy position, 397
    ergonomic considerations, 397
    hemostasis evaluation, 405–407, 406*f*
    Magrina Bookwalter self-retaining vaginal retractor., 398, 398*f*
    manual exposure, 398, 400*f*
    McCall culdoplasty, 407
    patient positioning, 408
    peritoneal reflection, 399–400
    posterior colpotomy, 400–402, 402*f*
    preemptive local anesthesia, 397
    secure blood supply, 403–405, 404*f*, 405*f*, 406*f*
    separate ligamentous attachments, 399*b*, 402–403, 403*f*
    transvaginal palpation, left ureter, 403, 404*f*
    ureteral palpation, 403, 404*f*
    vaginal cuff closing, 407

vaginal incision, 398, 400*f*
minimal descensus, 410–411
nulliparity, 395
perioperative antibiotics, 397
postoperative care, 413–414
preferred route for, 395–396
preoperative preparation, 396–397
procedural steps, 398, 399*b*
salpingo-oophorectomy technique at, 412, 412*f*
simulation in surgical education, 414
Vaginal hysteropexy comparative trials, 568–569
Vaginal intraepithelial neoplasia (VAIN), 469
$CO_2$ laser vaporization, 469–471
vaginal biopsy, 470–471
vaginectomy, 471–472, 472*b*
Vaginal mesh exposures, 615–616
Vaginal muscularis, 23
Vaginal myomectomy
cervix closure, 391
etiology, 391
hysteroscopy, 392
incision, 392
intraoperative instrument placement, 392*f*
Lahey clamp placement, 388–389, 392*f*
laparoscopic endoloops, 391
preoperative evaluation, 391
symptoms, 390–391
vaginal hemorrhage, 390–391
vasopressin administration, 391
Vaginal paravaginal repair, 591
Vaginal prolapse, 683–684
Vaginal trocar perforation, 614
Vaginal vault dissection, 572–573, 574*f*, 575*f*
Vaginal wall prolapse

colporrhaphy, 584–585
anterior, 584
posterior, 584
posterior, colporrhaphy, 594
symptoms associated with, 584–585
Vaginectomy, 471–472, 472*b*
Vaginoplasty for longitudinal vaginal septum, 784*b*
Vaginoscopy
equipment, 790–791, 791*f*
EUA with, 790–791, 790*t*, 791*f*, 791*b*
microperforation, 779, 779*f*
RVF, 644
vagina and cervix, 790, 790*t*, 791*f*
Vaporization
definition, 133–134
and desiccation, 140–141
Vascular injury
laparoscopy complications, 184, 184*f*
midurethral slings, complications from, 615
Vascular ligation, 731–732, 731*f*
arterial ligation, 731
internal iliac artery ligation, 731–732, 731*f*, 732*b*
ovarian artery ligation, 731, 732*b*
uterine artery ligation, 731, 732*b*
Vasoactive medications
algorithm, 238, 239*f*
types, 239*t*
Vasopressors or inotropes, 237–238, 239*t*
Vecchietti procedure, 779–781
Vein retractors, 118
Vena cava, 732–733
Venous bleeding, hemorrhage, 730
Venous thromboembolism (VTE), 532
anticoagulants

direct oral anticoagulants, 217
fondaparinux, 217
low molecular weight heparin, 217
unfractionated heparin, 217
warfarin, 217
chest radiograph, 216
computed tomography, 217
diagnosis, 215–217, 216*t*
duplex Doppler ultrasound imaging, 216–217
medical management, 218
treatment, 217–218
Venous thromboprophylaxis, 51–52
Venous thrombosis, cervical cancer, 524
Veress needle technique, initial laparoscopic entry, laparoscopy, 178, 178*f*, 179*f*
Verrucous carcinoma, 485, 505
Versapoint bipolar electrode, hysteroscopy, 261–262, 265*f*
Vertical incisions
closure of, 160–165, 162*f*, 163*f*
closed negative pressure wound therapy, 165
delayed primary and secondary closure, 163–164
drains, use of, 163
interrupted Smead-Jones closure technique, 163, 163*f*
negative pressure wound therapy, 164–165, 164*f*
suturing technique, 162
midline (median) incision, 156–158, 157*f*
paramedian incision, 158
Vesicovaginal fistulas (VVFs)
clinical presentation, 642, 642*t*
diagnosis and evaluation, 643–644
etiology and epidemiology, 639–642
nonobstetric lower reproductive tract fistulas, 641–642
obstetric lower reproductive tract fistulas, 639–641
lower reproductive tract fistula, surgical management, 646–666

conservative treatment, 645
fistula repair, principles of, 647–649, 648*t*
perioperative considerations, 647
repair, 663–664
surgical repair, 649–657
abdominal approach, 651–655, 652*f*–653*f*
conservative treatment, 645
diagnosis and evaluation, 642–645
retropubic-intravesical vesicovaginal fistula repair, 653–654, 654*f*
success rates, 656
surgical outcomes, 656–657
transperitoneal fistula repair, 652–653
urinary diversion for repair, 654–655, 655*f*
urinary incontinence, 657
vaginal approach, 649–651, 650*f*
vesicovaginal fistula repair, postoperative care after, 655–656
tissue interposition, 653*f*, 663–666
Vesicovaginal space, 34
Vestibular bulbs, 15, 38
Vestibule, 15, 17
location, 310
Vestibule disorders
chronic vulvar pain process, 310
cotton swab testing, 310
excision, 310–311
vestibulectomy, 310–311, 311*b*
VIN III (vulvar carcinoma in situ), 473, 473*f*
VIO® technology, bipolar electrosurgical instruments, 140
Visceral injury, vaginal hysterectomy complications, 413
Vision system, daVinci Surgical System, 191
Voiding dysfunction, pubovaginal sling, 605
Volutrauma, 242

von Willebrand disease (vWD), 249, 739*t*
VTE. *See* Venous thromboembolism (VTE)
Vulva
    anatomy of, 11–12, 12*f*–13*f*
    carcinoma, FIGO Staging for, 469, 471*t*
    layers of, 14
    lymphatic drainage of, 17–18, 17*f*
    pudendal nerve and vessels, 13*f*, 15
    subcutaneous tissues of, 12–14, 12*f*–13*f*
    superficial compartment, 13*f*, 14–15
    sweat glands, eccrine, 14
Vulvar ablative procedures
    carbon dioxide laser ablation, 309–310, 310*b*
    cryotherapy, 309, 309*t*, 309*b*
Vulvar abscesses, 230
Vulvar and vaginal cysts, lower genitourinary tract, 91, 91*f*
Vulvar biopsy
    complications, 304
    definition, 301
    indication, 301, 302*t*
    under local anesthesia, 301
    local anesthetic limitation, 301–302, 302*t*
    materials and equipment, 301–302
    postoperative management, 304
    procedural steps, 303*b*
    supplies, 301–302
    technique, 303*t*
        excisional biopsy, 303–304, 304*f*
        punch biopsy, 302, 303*f*
        shave biopsy, 302–303
    vulvar intraepithelial neoplasia, 473
    for women with bleeding disorders, 301
Vulvar cancer, 93, 469
    FIGO Staging for, 469, 471*t*

histologic subtypes, 469, 470*t*
HPV role, 469
postmenopausal disease, 469
surgery, 475–482
"butterfly" incision, 475
classic *en bloc* resection, 475, 476*f*
inguinofemoral lymphadenectomy, 480*f*, 479–481, 481*b*
inguinofemoral sentinel lymph node mapping, 481–482, 481*f*, 482*b*, 482*f*, 483*b*
invasive squamous cell carcinoma, 475*f*
management, 479, 479*f*
radical vulvectomy, 476–477, 476*f*–477*f*, 479*b*
treatment, 475
ultraradical surgery, 482–483
urethral resection, 478, 479*f*
Vulvar intraepithelial neoplasia (VIN), 308, 469
$CO_2$ laser vaporization, 474
simple vulvectomy, 474, 474*b*, 475*f*
surgical excision, 473
total simple vulvectomy, 474
Vulvar lesions, 301
Vulvar malignancies
Bartholin gland carcinoma, 484
basal cell carcinoma, 484
malignant melanoma, 483–484, 485*f*
Paget disease, 483, 483*f*, 484*f*
sarcomas, 484–485
verrucous carcinoma, 485
Vulvar reconstruction, 485
flaps for, 485, 486*f*
preoperative planning, 485
skin grafts, 485
Vulvovaginitis, 790
VVFs. *See* Vesicovaginal fistulas (VVFs)

## W


Warfarin, preoperative gynecologic patient care, 54
Watts (work), 131, 140
Waveform
    continuous *vs.* interrupted, 132–134, 134*t*
    effects and tissue contact, 134–135
    sinusoidal, 130, 132–133
Wedge resection of labia, 313, 314*b*, 314*f*
Weight loss, 606
Williams vaginoplasty, 779, 781*f*
Word catheter, 305–306, 305*f*
Wound
    classification, abdominal incisions, 150*t*
    gynecology, postoperative care, 215
Wound dehiscence, 151, 167–169
    and evisceration, 168
    incision types, 168
    management, 168–169
    pathogenesis, 168
Wound healing, 147–150, 148*f*
    cells involved, 149*t*
    classification, 150*t*
    hemostatic phase, 147–148
    inflammatory phase, 148
    proliferation, 149
    remodeling and maturation, 149–150, 150*t*
Wound management, pelvic inflammatory disease, 769–770
Wound remodeling and maturation, 149–150, 150*t*


## X


Xenon light generator, hysteroscopy, 260


## Z

Zeppelin (“Z”) clamps, 115